DIVISION 23: HEATING, VENTILATING, AND AIR-CONDITIONING

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COMMON HVAC REQUIREMENTS

SECTION 23 05 01

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Furnish labor, materials, and equipment necessary for completion of work as described in Contract Documents.

B. It is the intent of these specifications that the systems specified herein are to be complete and operational before being turned over to the owner. During the bidding process, the contractor is to ask questions or call to the engineer's attention any items that are not shown or may be required to make the system complete and operational. Once the project is bid and the contractor has accepted the contract, it is his responsibility to furnish and install all equipment and parts necessary to provide a complete and operational system without additional cost to the owner.

C. Furnish and install fire stopping materials to seal penetrations through fire rated structures and draft stops.

D. Includes But Not Limited To:
   1. General procedures and requirements for HVAC.

E. Related Sections:
   1. Section 23 0593: Testing, Adjusting, and Balancing for HVAC.

1.3 SUBMITTALS

A. Substitutions: By specific designation and description, standards are established for specialties and equipment. Other makes of specialties and equipment of equal quality will be considered provided such proposed substitutions are submitted to the Architect for his approval, complete with specification data showing how it meets the specifications, at least 5 working days prior to bid opening. A list of approved substitutions will be published as an addendum.
   1. Submit a single copy of Manufacturer's catalog data including Manufacturer's complete specification for each proposed substitution.
   2. The Architect or Engineer is to be the sole judge as to the quality of any material offered as an equal.

B. Product Data, Shop Drawings: Within 30 days after award of contract, submit 10 sets of Manufacturer's catalog data for each manufactured item.
   1. Literature shall include enough information to show complete compliance with Contract Document requirements.
   2. Mark literature to indicate specific item with applicable data underlined.
   3. Information shall include but not be limited to capacities, ratings, type of material used, guarantee, and such dimensions as are necessary to check space requirements.

4. When accepted, submittal shall be an addition to Contract Documents and shall be in equal force. No variation shall be permitted.
5. Even though the submittals have been accepted by the Engineer, it does not relieve the contractor from meeting all of the requirements of the plans and specifications and providing a complete and operational system.

C. Drawings of Record: One complete sets of blue line mechanical drawings shall be provided for the purpose of showing a complete picture of the work as actually installed.
1. These drawings shall serve as work progress report sheets. Contractor shall make notations neat and legible therein daily as the work proceeds.
2. The drawings shall be kept at the job at a location designated by the Mechanical Engineer.
3. At completion of the project these "as-built" drawings shall be signed by the Contractor, dated, and returned to the Architect.

D. Operating Instructions and Service Manual: The Mechanical Contractor shall prepare 2 copies of an Operation and Maintenance Manual for all mechanical systems and equipment used in this project. Manuals shall be bound in hard-backed binders and the front cover and spine of each binder shall indicate the name and location of the project. Use plastic tab indexes for all sections. Provide a section for each different type of equipment item. The following items shall be included in the manual, together with any other pertinent data. This list is not complete and is to be used as a guide.
1. Provide a master index at the beginning of the manual showing all items included.
2. The first section of the manual shall contain:
    a. Names, addresses, and telephone numbers of Architect, Mechanical Engineer, Electrical Engineer, General Contractor, Plumbing Contractor, Sheet Metal Contractor, and Temperature Control Contractor.
    b. List of Suppliers which shall include a complete list of each piece of equipment used with the name, address, and telephone number of vendor.
    c. General Description of Systems including –
        1) Location of all major equipment
        2) Description of the various mechanical systems
        3) Description of operation and control of the mechanical systems
        4) Suggested maintenance schedule
    d. Copy of contractor's written warranty
3. Provide a copy of approved submittal literature for each piece of equipment.
4. Provide maintenance and operation literature published by the manufacturer for each piece of equipment which includes: oiling, lubrication and greasing data; belt sizes, types and lengths; wiring diagrams; step-by-step procedure to follow in putting each piece of mechanical equipment in operation.
5. Include parts numbers of all replaceable items.
6. Provide control diagram and operation sequence, along with labeling of control piping and instruments to match diagram.
7. Include a valve chart indicating valve locations.

E. Include air balance and/or water balance reports.

1.4 SUBMITTALS FOR COMMON HVAC REQUIREMENTS

A. Samples: Sealer and gauze proposed for sealing ductwork.

B. Quality Assurance / Control:

1. Manufacturer's installation manuals providing detailed instructions on assembly, joint sealing, and system pressure testing for leaks.
2. Specification data on sealer and gauze proposed for sealing ductwork.

C. Quality Assurance
1. Requirements: Construction details not specifically called out in Contract Documents shall conform to applicable requirements of SMACNA HVAC Duct Construction Standards.
2. Pre-Installation Conference: Schedule conference immediately before installation of ductwork.

1.5 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
1. Perform work in accordance with applicable provisions of local and state Plumbing Code, Gas Ordinances, and adoptions thereof. Provide materials and labor necessary to comply with rules, regulations, and ordinances.
2. In case of differences between building codes, state laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify Architect in writing of such differences.

B. Applicable Specifications: Referenced specifications, standards, and publications shall be of the issues in effect on date of Advertisement for Bid.
1. "Heating, Ventilating and Air Conditioning Guide" published by the American Society of Heating and Air Conditioning Engineers.
2. "Engineering Standards" published by the Heating, Piping, and Air Conditioning Contractors National Association.
3. "2015 International Building Code", "2015 International Mechanical Code", "2015 International Plumbing Code" and "2015 International Fire Code" as published by the International Conference of Building Officials.
4. "National Electrical Code" as published by the National Fire Protection Association.
5. "2015 International Energy Conservation Code ".

C. Identification: Motor and equipment name plates as well as applicable UL and AGA labels shall be in place when Project is turned over to Owner.

1.6 INSPECTIONS AND PERMITS

A. Pay for permits, fees, or charges for inspection or other services. Local and state codes and ordinances must be properly executed without expense to Owner and are considered as minimum requirements. Local and state codes and ordinances do not relieve the Contractor from work shown that exceeds minimum requirements.

1.7 ADDITIONAL WORK:

A. Design is based on equipment as described in the drawing equipment schedule. Any change in foundation bases, electrical wiring, conduit connections, piping, controls and openings required by alternate equipment submitted and approved shall be paid for by this division. All work shall be in accordance with the requirements of the applicable sections.

PART 2 - PRODUCTS FOR COMMON HVAC REQUIREMENTS

A. Finishes, Where Applicable: Colors as selected by Architect.

B. Duct Hangers:
   1. One inch 25 mm by 18 ga 1.27 mm galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 96 inches 2 400 mm apart. Do not use wire hangers.
   2. Attaching screws at trusses shall be 2 inch 50 mm No. 10 round head wood screws. Nails not allowed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Site Inspection:
   1. Examine premises and understand the conditions which may affect performance of work of this Division before submitting proposals for this work.
   2. No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.

B. Drawings:
   1. Mechanical drawings show general arrangement of piping, ductwork, equipment, etc, and do not attempt to show complete details of building construction which affect installation. This Contractor shall refer to architectural, structural, and electrical drawings for additional building detail which affect installation of his work.
      a. Follow mechanical drawings as closely as actual building construction and work of other trades will permit.
      b. No extra payments will be allowed where piping and/or ductwork must be offset to avoid other work or where minor changes are necessary to facilitate installation.
      c. Everything shown on the mechanical drawings shall be the responsibility of Mechanical Contractor unless specifically noted otherwise.
   2. Consider architectural and structural drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over mechanical drawings.
   3. Because of small scale of mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions. Do not scale drawings for locations of equipment or piping. Refer to large scale dimensioned drawings for exact locations.

C. Insure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents.
   1. If approval is received to use other than specified items, responsibility for specified capacities and insuring that items to be furnished will fit space available lies with this Division.
   2. If non-specified equipment is used and it will not fit job site conditions, this Contractor assumes responsibility for replacement with items named in Contract Documents.

3.2 PREPARATION

A. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.

1. Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
2. Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
3. Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

3.3 INSTALLATION

A. Arrange pipes, ducts, and equipment to permit ready access to valves, unions, traps, starters, motors, control components, and to clear openings of doors and access panels.

3.4 STORAGE AND PROTECTION OF MATERIALS:

A. Provide storage space for storage of materials and assume complete responsibility for losses due to any cause whatsoever. Storage shall not interfere with traffic conditions in any public thoroughfare.

B. Protect completed work, work underway, and materials against loss or damage.

C. Close pipe openings with caps or plugs during installation. Cover fixtures and equipment and protect against dirt, or injury caused by water, chemical, or mechanical accident.

3.5 EXCAVATION AND BACKFILL

A. Perform necessary excavation of whatever substance encountered for proper laying of all pipes and underground ducts.
1. Excavated materials not required for fill shall be removed from site as directed by Engineer.
2. Excavation shall be carried low enough to allow a minimum coverage over underground piping of 5'-0" or to be below local frost level.
3. Excess excavation below required level shall be backfilled at Contractor's expense with earth, sand, or gravel as directed by Engineer. Tamp ground thoroughly.
4. Ground adjacent to all excavations shall be graded to prevent water running into excavated areas.

B. Backfill pipe trenches and allow for settlement.
1. Backfill shall be mechanically compacted to same density as surrounding undisturbed earth.
2. Cinders shall not be used in backfilling where steel or iron pipe is used.
3. No backfilling shall be done until installation has been approved by the Engineer.

3.6 COOPERATION

A. Cooperate with other crafts in coordination of work. Promptly respond when notified that construction is ready for installation of work under Division 23000. Contractor will be held responsible for any delays which might be caused by his negligence or failure to cooperate with the other Contractors or crafts.

3.7 SUPERVISION

A. Provide a competent superintendent in charge of the work at all times. Anyone found incompetent shall be removed at once and replaced by someone satisfactory, when requested by the Architect.

3.8 INSTALLATION CHECK:

A. An experienced, competent, and authorized representative of the manufacturer or supplier of each item of equipment indicated in the equipment schedule shall visit the project to inspect, check, adjust if necessary, and approve the equipment installation. In each case, the equipment supplier's representative shall be present when the equipment is placed in operation. The equipment supplier's representative shall revisit the project as often as necessary until all trouble is corrected and the equipment installation and operation is satisfactory to the Engineer.

B. Each equipment supplier's representative shall furnish to the Owner, through the Engineer, a written report certifying the following:
   1. Equipment has been properly installed and lubricated.
   2. Equipment is in accurate alignment.
   3. Equipment is free from any undue stress imposed by connecting piping or anchor bolts.
   4. Equipment has been operated under full load conditions.
   5. Equipment operated satisfactorily.

C. All costs for this installation check shall be included in the prices quoted by equipment suppliers.

3.9 CLEANING EQUIPMENT AND PREMISES

A. Properly lubricate equipment before Owner's acceptance.

B. Clean exposed piping, ductwork, equipment, and fixtures. Repair damaged finishes and leave everything in working order.

C. Remove stickers from fixtures and adjust flush valves.

D. At date of Substantial Completion, air filters shall be new, clean, and approved by Owner's representative.

E. Trap elements shall be removed during cleaning and flushing period. Replace trap elements and adjust after cleaning and flushing period.

3.10 TESTS

A. No piping work, fixtures, or equipment shall be concealed or covered until they have been inspected and approved by the inspector. Notify inspector when the work is ready for inspection.

B. All work shall be completely installed, tested as required by Contract Documents and the city and county ordinances and shall be leak-tight before the inspection is requested.

C. Tests shall be repeated to the satisfaction of those making the inspections.

D. Water piping shall be flushed out, tested at 100 psi and left under pressure of supply main or a minimum of 40 psi for the balance of the construction period.

3.11 WARRANTEE

A. Contractor shall guarantee work under Division 23 to be free from inherent defects for a period of one year from acceptance.
   1. Contractor shall repair, revise or replace any and all such leaks, failure or inoperativeness due to defective work, materials, or parts free of charge for a period of one year from final acceptance, provided such defect is not due to carelessness in operation or maintenance.
   2. In addition, the Contractor shall furnish all refrigeration emergency repairs, emergency service and all refrigerant required due to defective workmanship, materials, or parts for a period of one year from final acceptance at no cost to the Owner, provided such repairs, service and refrigerant are not caused by lack of proper operation and maintenance.

B. In addition to warrantee specified in General Conditions, heating, cooling, and plumbing systems are to be free from noise in operation that may develop from failure to construct system in accordance with Contract Documents.

3.12 SYSTEM START-UP, OWNER'S INSTRUCTIONS

A. Off-Season Start-up
   1. If Substantial Completion inspection occurs during heating season, schedule spring start-up of cooling systems. If inspection occurs during cooling season, schedule autumn start-up for heating systems.
   2. Notify Owner 7 days minimum before scheduled start-up.
   3. Time will be allowed to completely service, test, check, and off-season start systems. During allowed time, train Owner's representatives in operation and maintenance of system.
   4. At end of off-season start-up, furnish Owner with letter confirming that above work has been satisfactorily completed.

B. Owner's Instructions
   1. Instruct building maintenance personnel and Owner Representative in operation and maintenance of mechanical systems utilizing Operation & Maintenance Manual when so doing.
   2. Minimum instruction periods shall be as follows –
      a. Mechanical - Four hours.
      b. Temperature Control - Four hours.
      c. Refrigeration - Two hours.
   3. Instruction periods shall occur after Substantial Completion inspection when systems are properly working and before final payment is made.
   4. None of these instructional periods shall overlap another.

3.13 PROTECTION

A. Do not run heat pump, air handling units, fan coil units, or other pieces of equipment used for moving supply air without proper air filters installed properly in system.

B. The mechanical systems are not designed to be used for temporary construction heat. If any equipment is to be started prior to testing and substantial completion, such equipment will be returned to new condition with full one year warranties, from date of substantial completion after any construction use. This includes, but is not necessarily limited to: Equipment, filters, ductwork, fixtures, etc.

3.14 COMMON HVAC REQUIREMENTS:

A. INSTALLATION
1. During installation, protect open ends of ducts by covering with plastic sheet tied in place to prevent entrance of debris and dirt.
2. Make necessary allowances and provisions in installation of sheet metal ducts for structural conditions of building. Revisions in layout and configuration may be allowed, with prior written approval of Architect. Maintain required airflows in suggesting revisions.
3. Hangers And Supports:
   a. Install pair of hangers close to each transverse joint and elsewhere as required by spacing indicated in table on Drawings.
   b. Install upper ends of hanger securely to floor or roof construction above by method shown on Drawings.
   c. Attach strap hangers to ducts with cadmium-plated screws. Use of pop rivets or other means will not be accepted.
   d. Where hangers are secured to forms before concrete slabs are poured, cut off flush all nails, strap ends, and other projections after forms are removed.
   e. Secure vertical ducts passing through floors by extending bracing angles to rest firmly on floors without loose blocking or shimming. Support vertical ducts, which do not pass through floors, by using bands bolted to walls, columns, etc. Size, spacing, and method of attachment to vertical ducts shall be same as specified for hanger bands on horizontal ducts.

B. CLEANING
1. Clean interior of duct systems before final completion.

END OF SECTION

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

SECTION 23 05 53

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install identification of equipment and piping as described in Contract Documents.

B. Mechanical Contractor shall touch-up equipment where factory paint has been damaged. Repaint entire item where more than 20 percent of the surface is involved.

C. Primary painting of walls, ceilings, ductwork, piping and plenums is covered in the general painting section of these Contract Documents.

PART 2 - PRODUCTS

2.1 PAINT

A. Benjamin Moore Impervo or equivalent by Paint Manufacturer approved in Section 09 900.

B. Use appropriate primer.

2.2 LABELS

A. Black Formica with white reveal on engraving.

2.3 CODED BANDS

A. Using colored bands and arrows to indicate supply and return, with colored reflective tape, color code all piping installed in this contract at not more than 20-foot intervals, at equipment, at walls, etc., in accordance with ANSI Standards.

B. Approved Manufacturers:
   1. Seton
   2. Craftmark

2.4 PIPE IDENTIFICATION

A. In addition to the colored bands, stencil with black paint in 1/2 inch high letters a symbol and directional arrow for all fluids handled or use Seaton coded and colored pipe markers and arrows to meet ANSI Standards.

2.5 EQUIPMENT IDENTIFICATION

A. Provide an engraved plastic plate for each piece of equipment stating the name of the item, symbol number, area served, and capacity. Label all control components with

plastic embossed mechanically attached labels. Sample:
1. Supply Fan SF-1 - North Classrooms
2. 10,000 CFM @ 2.5"

2.6 VALVE IDENTIFICATION

A. Make a list of and tag all valves installed in this work.
1. Valve tags shall be of brass, not less than 1"x2" size, hung with brass chains.
2. Tag shall indicate plumbing or heating service.

PART 3 - EXECUTION

3.1 APPLICATION

A. Engraved Plates:
1. Identify thermostats and control panels in mechanical rooms, furnaces, boilers and hot water heating specialties, duct furnaces, air handling units, electric duct heaters, and condensing units with following data engraved and fastened to equipment with screws –
a. Equipment mark noted on Drawings (i.e., SF-1)
b. Area served (i.e., North Classrooms)
c. Capacity (10,000 CFM @ 2.5)

B. Stenciling:
1. Locate identifying legends and directional arrows at following points on each piping system –
a. Adjacent to each item of equipment and special fitting.
b. At point of entry and exit where piping goes through wall.
c. On each riser and junction.
d. Every 50 feet on long continuous lines.
2. Hot Water Heating, Gas, & Valve Identification –
a. Identify specific pipe contents by stenciling pipe with written legend and placing of arrows to indicate direction of flow.

C. Painting:
1. Background Color - Provide by continuous painting of piping.

Symbol	Name	Color
HWH	Hot Water Heating	Green
NG	Natural Gas	Yellow
FS	Fire Sprinkler	Red

2. Identification stenciling and flow arrows shall be following colors for proper contrast:

Arrows & ID Stenciling	Color Shade of Pipe
White	Red, Grays, & black
Black	Yellows, Oranges, Greens, & White

END OF SECTION

TESTING, ADJUSTING, AND BALANCING

SECTION 23 05 93

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Division 23 0501 - Common HVAC Requirements and Basic Mechanical Materials and Methods Sections apply to work of this section.

1.2 SUMMARY SCOPE

A. This Section includes TAB to produce design objectives for the following:
   1. Air Systems.
      a. Rooftop Units.
      b. Exhaust Fans.
      c. VAV Boxes.
   2. Hydronic Piping Systems.
      a. Primary - Secondary Systems
      b. Boilers
      c. Pumps

1.3 SUBMITTALS

A. Agency Data:
   1. Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below. The firm or individuals performing the work herein specified may not be the installing firm.

B. Engineer and Technicians Data:
   1. Submit proof that the Test and Balance Engineer assigned to supervise the procedures, and the technicians proposed to perform the procedures meet the qualifications specified below.

C. Procedures and Agenda: Submit a synopsis of the testing, adjusting, and balancing procedures and agenda proposed to be used for this project.

D. Sample Forms: Submit sample forms, if other than those standard forms prepared by the AABC or NEBB are proposed.

E. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below.
   1. Draft Reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.

2. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 4 complete sets of final reports.
3. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
    a. General Information and Summary
    b. Air Systems
    c. Temperature Control System Verification.

F. Report Contents: Provide the following minimum information, forms, and data:
1. General information and Summary: Inside cover sheet to identify testing, adjusting, balancing agency, Contractor, Owner, Engineer, and Project. Include addresses and contact names and telephone numbers. Also include a certification sheet containing the seal and name, address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentation used for the procedures along with the instrument calibration sheet.
2. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC or NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form. The report shall contain the following information, and all other data resulting from the testing, adjusting, and balancing work:
    a. All nameplate and specification data for all air handling equipment and motors.
    b. Actual metered running amperage for each phase of each motor on all pumps and air handling equipment.
    c. Actual metered voltage at air handling equipment (phase-to-phase for all phases).
    d. Fan RPM for each piece of air handling equipment.
    e. Total actual CFM being handled by each piece of air handling equipment.
    f. Actual CFM of systems by rooms.
3. Certify that all smoke and fire dampers operate properly and can be reset under actual system operating conditions.

G. Calibration Reports:
1. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

1.4 CERTIFICATION

A. Agency Qualifications:
1. Employ the services of a certified testing, adjusting, and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust, and balance the building mechanical systems identified above, to produce the design objectives. Services shall include checking installations for conformity to design, measurement, and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, recording and reporting the results, and operation of all systems to demonstrate satisfactory performance to the owner.

2. The testing, adjusting, and balancing agency certified by National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one person certified by NEBB or AABC as a Test and Balance supervisor, and a registered professional mechanical engineer, licensed in the state where the work will be performed.

B. Codes and Standard:
   1. NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
   2. AABC: "National Standards for Total System Balance."
   3. ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.

1.5 PROJECT CONDITIONS

A. Systems Operation: Systems shall be fully operation and clean prior to beginning procedures.

1.6 SEQUENCING AND SCHEDULING

A. Test, adjust, and balance the air systems before hydronic, steam, and refrigerant systems within +10% to -5% of contract requirements.

B. The report shall be approved by the Engineer. Test and balance shall be performed prior to substantial completion.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

A. Before operating the system, perform these steps.
   1. Obtain design drawings and specifications and become thoroughly acquainted with the design intent.
   2. Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return, and exhaust) and temperature control diagrams.
   3. Compare design to installed equipment and field installations.
   4. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.
   5. Check filters for cleanliness and to determine if they are the type specified.
   6. Check dampers (both volume and fire) for correct and locked position. Check automatic operating and safety controls and devices to determine that they are properly connected, functioning, and at proper operating setpoint.
   7. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a cross-check with required fan volumes.
   8. Determine best locations in main and branch ductwork for most accurate duct traverses.
   9. Place outlet dampers in the full open position.
   10. Prepare schematic diagrams of system "As-Built" ductwork and piping layouts to facilitate reporting.
   11. Lubricate all motors and bearings.
   12. Check fan belt tension.

13. Check fan rotation.

3.4 PROCEDURES FOR HYDRONIC SYSTEMS

B. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
   1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
   2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
   3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
   4. Report flow rates that are not within plus or minus 5 percent of design.

C. Set calibrated balancing valves, if installed, at calculated presettings.

D. Measure flow at all stations and adjust, where necessary, to obtain first balance.
   1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

E. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

F. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
   1. Determine the balancing station with the highest percentage over indicated flow.
   2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
   3. Record settings and mark balancing devices.

G. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

H. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.5 MEASUREMENTS

A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.

B. Provide instruments meeting the specifications of the referenced standards.

C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.

D. Apply instrument as recommended by the manufacturer.

E. Use instruments with minimum scale and maximum subdivisions and with scale ranges

proper for the value being measured.

F. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5%. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.

G. Take all readings with the eye at the level of the indicated value to prevent parallax.

H. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.

I. Take measurements in the system where best suited to the task.

3.6 PERFORMING TESTING, ADJUSTING, AND BALANCING

A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards. Balancing of the air systems and hydronic systems shall be achieved by adjusting the automatic controls, balancing valves, dampers, air terminal devices, and the fan/motor drives within each system.

B. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

C. Patch insulation, ductwork, and housings, using materials identical to those removed.

D. Seal ducts and piping, and test for and repair leaks.

E. Seal insulation to re-establish integrity of the vapor barrier.

F. Adjust timing relays of environmental equipment motor reduced voltage starters to the optimum time period for the motor to come up to the maximum reduced voltage speed and then transition to the full voltage speed to prevent damage to motor, and to limit starting current spike to the lowest possible and practical.

G. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.

H. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.7 RECORD AND REPORT DATA

A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.

B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

C. Report shall be certified and stamped by a registered professional mechanical engineer employed by the agency and licensed in the state where the work will be performed.

D. Engineer is to provide a floor plan and test and balance contractor to include the plan in test and balance report and identify actual cfm on drawing or number the diffusers to

match report.

3.8 DEMONSTRATION

A. If requested, testing, adjusting, and balancing agency shall conduct any or all of the field tests in the presence of the engineer.

B. Agency shall include a maximum of one (1) call back to the project within the one year warranty period to make additional adjustments if requested by the engineer.

END OF SECTION

MECHANICAL INSULATION AND FIRE STOPPING

SECTION 23 07 10

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install mechanical insulation and fire stopping as described in Contract Documents including but not limited to the following:
   1. Ductwork Insulation
   2. Heating Piping Insulation
   3. Boilers, Tanks, Headers, and Breechings
   4. Fire Stopping

1.3 QUALITY ASSURANCE

A. Insulation shall have composite (insulation, jacket or facing and adhesive used to adhere facing or jacket to insulation) fire and smoke hazard ratings as tested by Procedure ASTM E-84, NFPA 255 and UL 723 not exceeding: Flame Spread of 25 and Smoke Developed of 50.

B. Insulation Contractor shall certify in writing, prior to installation, that all products to be used will meet the above criteria.

C. Accessories, such as adhesives, mastics, cements, and tapes, for fittings shall have the same component ratings as listed above.

D. Products, or their shipping cartons, shall bear a label indicating that flame and smoke ratings do not exceed above requirements.

E. Any treatment of jacket or facings to impart flame and smoke safety shall be permanent.

F. The use of water-soluble treatments is prohibited.

END OF SECTION

PREMOLDED ONE PIECE PVC FITTINGS INSULATION

SECTION 23 07 14

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install premolded one piece PVC fittings insulation as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Fittings shall be UL rated 25/50 PVC.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Approved Manufacturers:
   1. Zeston

PART 3 - EXECUTION

3.1 INSTALLATION

A. Where factory premolded one piece PVC insulating fitting covers are to be used, proper factory precut Hi-Lo Temp insula tion shall be applied to the fitting. Ends of Hi-Lo Temp insulation shall be tucked snugly into throat of fitting and edges adjacent to pipe covering tufted and tucked in. Fully insulate pipe fittings. One piece PVC fitting cover is then secured by stapling, tack fastening, banding or taping ends to adjacent pipe covering.

B. Cold:
   1. Chilled water systems shall be insulated as "A" above and have all seam edges of cover sealed with Zeston's vapor barrier adhesive or equal.
   2. Circumferential edges of cover shall be wrapped with Zeston's vapor barrier pressure sensitive color matched Z tape.
   3. Tape shall extend over adjacent pipe insulation and have an overlap on itself at least 2" on downward side.

C. Hot:
   1. On fittings where temperature exceeds 250 degrees F., two layers of factory precut Hi-Lo Temp insulation inserts shall be applied with a few wrappings of twine on first layer, to be sure there are no voids or hot spots. Fitting cover shall then be applied over Hi-Lo Temp insulation as described above in "A."

END OF SECTION

HOT WATER HEATING & RETURN PIPING INSULATION

SECTION 23 07 15

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install insulation on piping mains, branches, risers, fittings, and valves, pump bodies and flanges as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MATERIAL

A. 3 lb./cu.ft. heavy density fiberglass with fire retardant vapor barrier jacket with self sealing laps. Thickness shall be 1-1/2 inches on heating supply and return lines.

B. Approved Manufacturers:
1. Owens-Corning Fiberglass heavy density with ASJ-SSL jacket
2. Equals by Johns-Manville or CTM.
3. Zeston covers for valves and fittings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pipes:
1. Install in accordance with manufacturer's directions on clean dry pipes.
2. Butt joints firmly together.
3. Seal vapor barrier longitudinal seam overlap with vapor barrier adhesive.
4. Wrap butt joints with four inch strip of vapor barrier jacket material cemented with vapor barrier adhesive.
5. Finish with bands applied at mid-section and at each end of insulation.

B. Valves & Fittings:
1. Insulate and finish by one of following methods:
   a. With hydraulic setting insulating cement, or equal, to thickness equal to adjoining pipe insulation.
   b. With segments of molded insulation securely wired in place.
   c. With prefabricated covers made from molded pipe insulation finished with vapor barrier adhesive.
   d. Zeston covers and factory applied insulation diapers.
2. Finish fittings and valves with four ounce canvas and coat with vapor barrier adhesive or Zeston covers.

END OF SECTION

DUCTWORK INSULATION

SECTION 23 07 16

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install insulation on air ducts outside building insulation envelope as described in Contract Documents.

B. Furnish and install insulation on fresh air ducts and combustion air ducts within building insulation envelope as described in Contract Documents.

C. Furnish and install insulation on other air ducts where indicated on Drawings.

PART 2 - PRODUCTS

2.1 INSULATION

A. 1-1/2 inch thick fiberglass with aluminum foil scrim kraft facing and have a density of one lb/cu ft.

B. Approved Manufacturers:
1. Manville Microlite FSK
2. CSG Type IV standard duct insulation
3. Owens-Corning FRK
4. Knauf (Duct Wrap FSK)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct wrap in accordance with Manufacturer's recommendations.

B. Do not compress insulation except in areas of structural interference.

C. Completely seal joints.

END OF SECTION

ROUND SUPPLY DUCT INSULATION

SECTION 23 07 17

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install round supply duct insulation as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Insulation shall be UL rated with FSK (foil-skrim-kraft) facing.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Fiberglass blanket insulation

B. Approved Manufacturers:
   1. Johns-Manville R-4 Microlite (R-4 does not include the vapor barrier material).
   2. Owens-Corning faced duct wrap insulation FRK-25 ED-150
   3. Certainteed Standard Duct Wrap.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Insulate round air supply ducts.

B. Facing shall overlap 2" at joints and shall be secured with outward clinch staples on 4" centers.

C. Ducts over 30" in width shall have spot application of adhesive, weld pins or metal screws and caps on not more than 18" centers applied to underside.

D. 3" wide vapor barrier paper shall be applied over seams and sealed with vapor barrier adhesive.

E. Insulate attenuators.

F. Insulate high and low pressure flex ducts.

END OF SECTION

DUCT LINING

SECTION 23 07 18

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install acoustic lining in following above ground metal ductwork as described in Contract Documents unless detailed otherwise:
   1. Outside air
   2. Supply air
   3. Return air
   4. Mixed air
   5. Transfer air
   6. Relief air
   7. Elbows, fittings, and diffuser drops greater than 12 inches in length.

1.3 SYSTEM DESCRIPTION

A. Duct dimensions shown on Drawings are for free area inside insulation. Allowance must be made for insulation, where applicable.

1.4 RATINGS:

A. Material shall have maximum air friction correction factor of 1.10 at 1000 FPM velocity and have a minimum sound absorption coefficient NRC of .60.

PART 2 - PRODUCTS

2.1 DUCT LINER

A. One inch thick, 1-1/2 lb density fiberglass, factory edge coated.

B. Duct lining materials are to meet the requirements of UL 181 for mold, humidity, and erosion resistance.

C. Approved Manufacturers:
   1. Certainteed Ultralite 150 Certa Edge Coat
   2. Knauf - Type M
   3. Manville - Lina-Coustic
   4. Owen Corning Fiberglas - Aeroflex

2.2 ADHESIVE

A. Water Base Type:
   1. Cain - Hydrotak
   2. Duro Dyne - WSA
   3. Kingco - 10-568
   4. Miracle - PF-101
   5. Mon-Eco - 22-67
   6. Techno Adhesive - 133

B. Solvent Base (non-flammable) Type:

1. Cain - Safetak
2. Duro Dyne - FPG
3. Kingco - 15-137
4. Miracle - PF-91
5. Mon-Eco - 22-24
6. Techno Adhesive - 'Non-Flam' 106

C. Solvent Base (flammable) Type:
1. Cain - HV200
2. Duro Dyne - MPG
3. Kingco - 15-146
4. Miracle - PF-96
5. Mon-Eco - 22-22
6. Techno Adhesive - 'Flammable' 106

2.3 FASTENERS

A. Adhesively secured fasteners not allowed.

B. Approved Manufacturers:
1. AGM Industries Inc - "DynaPoint" Series DD-9 pin
2. Cain
3. Duro Dyne
4. Omark dished head "Insul-Pins"
5. Grip nails may be used if each nail is installed by "Grip Nail Air Hammer" or by "Automatic Fastener Equipment" in accordance with Manufacturer's recommendations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install mat finish surface on air stream side. Secure insulation to cleaned sheet metal duct with continuous 100% coat of adhesive and with 3/4 inch long mechanical fasteners 12 inches on center maximum unless detailed otherwise on Drawings. Pin all duct liner.

B. Accurately cut liner and thoroughly coat ends with adhesive. Butt joints tightly. Top and bottom sections of insulation shall overlap sides. If liner is all one piece, folded corners shall be tight against metal. Ends shall butt tightly together.

C. In casings and plenums further contain insulation with wire mesh.

3.2 FIELD QUALITY CONTROL

A. If insulation is installed without longitudinal and end joints butted together, installation will be rejected and work removed and replaced with work that conforms to this Specification.

B. Insulation shall be installed in accordance with Duct Liner Application Standard SMACNA Manual 15.

3.3 ADJUSTING, CLEANING

A. Keep duct liner clean and free from dust. At completion of project, vacuum duct liner if it is dirty or dusty.

END OF SECTION

FIRE STOPPING

SECTION 23 08 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install fire stopping as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Fire stopping material shall meet ASTM E814, E84 and be UL listed.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Material shall be flexible, long lasting, intumescent acrylic seal to accommodate vibration and building movement.

B. Caulk simple penetrations with gaps of 1/4" or less with:
1. Dow Corning Fire Stop Sealant
2. Pensil 300

C. Caulk multiple penetrations and/or penetrations with gaps in excess of 1/4" with:
1. Dow Corning Fire Stop Foam
2. Pensil 200
3. IPC flame safe FS-1900
4. Tremco “Tremstop 1A”

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow manufacturer's installation instructions explicitly.

B. Seal penetrations of ductwork, piping, and other mechanical equipment through one-hour and two-hour rated partitions as shown on Architectural and Mechanical Drawings.

C. Install fire stopping material on clean surfaces to assure adherence.

END OF SECTION

TEMPERATURE CONTROLS (DDC)

SECTION 23 09 53

PART 1 - SYSTEM OVERVIEW

1.1 DDC CONTROL SYSTEM

A. Statement of Intent: The intent of this specification is to provide a high-quality Direct Digital Control system at Chubbuck City Hall. In order to maintain seamless interface and consistency of user screens all new control hardware must be programmed using the Eikon™ control programming utility. System must continue to have realtime presentation of these programs showing current operating parameters and conditions. Graphical User Interface screens must be developed using ViewBuilder™ graphics development software.

B. Specification Compliance: These specifications are intended to provide a minimum capability for the DDC system. Manufacturer's data sheets included in the submittals will be reviewed to verify significant hardware and software system features. Key system features must be documented by manufacturer's data sheets in the submittals or by demonstration of an existing installation. Anyone wishing approval to bid must coordinate with the Mechanical Engineer and School District personnel not later than 10 days prior to bid date for a system demonstration of integration capabilities to existing front end software as noted above.

C. Approved DDC Contractor and System
   1. DDC Control System shall be:
   2. Automated Logic WebCTRL by Clima-Tech Corporation
   3. Or Prior Approved 2 weeks in advance by Engineer

1.2 SCOPE OF WORK

A. Control Hardware and Software: Automatic Temperature Control Contractor shall be responsible to furnish and install all control hardware and software necessary for complete DDC control system as specified. ATC contractor shall furnish all modules, temperature sensors, flow sensors, humidity sensors, IAQ sensors, control valves, control valve actuators, dampers, damper actuators and any other items necessary for a complete system and sequence of control.

B. Specifically the ATC Contractor shall furnish the following:
   1. Individual unitary control modules for each unitary system:
      a. VAV Boxes
      b. Air Handling Units

C. Individual control modules for all non unitary air handlers or package units.

B. General purpose modules for control of central fan, pump, or boiler operation:
   1. Hot Water Systems

C. Control Wiring and Interface to Line Voltage Control
   1. ATC Contractor shall be responsible for all wiring required for this project regardless of VA requirements.

F. Commissioning: ATC Contractor shall be responsible for self-commissioning of all hardware and software furnished with the project. Completed field commissioning sheets shall be included with the final "as-built" O&M manuals. These sheets shall include validation check

fields for all physical and LAN inputs and outputs and graphics for each operating unit or system within the facility. Each system and point shall be listed, using logical names for future reference by the owner. Commissioning shall include calibration and verification of operation of each I/O and graphic field. Functional commissioning of software programming to meet sequences of operation as submitted and approved shall be verified on the field commissioning sheets.

G. Training and Technical Support: Contractor shall provide 8 hours of training to owner representatives on operation and servicing of automatic temperature control system. Training shall be oriented to making the owner self sufficient in the day to day use and operation of the DDC system. Additionally the training shall include information specifically focused on showing the owners representative methods of troubleshooting the mechanical systems using the DDC system. For this purpose, the trainer must be well grounded in both DDC system operation and in mechanical systems service.

H. The contractor shall provide unlimited phone technical support to the owners representative during the one year warranty period. If the technical support location of the contractor is outside of the toll free calling area for the customer, the contractor shall have a toll free number or accept collect calls for the purpose of providing technical support.

1.3 SUBMITTALS AND O&M MANUALS

A. Submittals
   1. Submittals shall include the following sections:
   2. Shop Drawings with:
      a. Title Page
      b. Table of Contents
      c. Typical Device Wiring Drawings
      d. Summary Bill of Materials
      e. Local Area Network Drawings
      f. Drawings for all operating systems showing both equipment and module connections (Note: drawings for individual operating systems shall include individual Bills of Materials)

B. Sequences of Operation
   1. Manufacturers specification data sheets for all control modules, sensors, dampers, valves, actuators, flow switches, current sensors and transducers required in the project.
   2. If the contractor wishes to substitute any item after approval of submittal they shall submit appropriate data sheets for approval before including substituted product on the project.

C. O&M Manuals
   1. O&M Manuals shall be furnished upon project completion and include technical instructions for all items originally included in the submittal with “as built” modifications and completed Commissioning Worksheets. O&M Manuals shall be in a separate three ring binder. Contractor’s toll free technical support number or the words “Call Collect” with the contractor’s regular phone number shall be on the front of the manual.

1.4 SYSTEM SOFTWARE

A. System Software
   1. All operating program and site specific software shall be furnished to the owner on 3½” diskettes or CD ROM disks.

PART 2 - CONTRACTOR CAPABILITY

2.1 Contractor shall maintain toll-free technical support phone line or accept collect phone calls during warranty period. Contractor shall provide service within 24 hours. Contractor service and installation technicians shall be technically proficient in both control systems and mechanical service.

PART 3 - PRODUCT CAPABILITY - HARDWARE

3.1 SYSTEM SERVER

A. Software shall be installed on owner's existing WebCTRL server.

3.2 FIELD HARDWARE

A. BACnet Compatibility

1. The system shall be fully native BACnet at the time of installation. The system shall use BACnet as the native communication protocol between distributed controllers communicating on the controller network (i.e. Field Bus) and must, as a minimum, support the following Objects and Application Services (Conformance Class 3):

B. Objects	Binary Input	Services>	Readproperty
	Binary Output		Writeproperty
	Binary Value		I-Am
	Analog Input		I-Have
	Analog Output		ReadMultiple Property
	Analog Value		WriteMultiple Property
	Calendar		Who-Has
	Schedules		Who-Is

C. Distributed Control: System shall observe the concept of distributed control. All modules shall have "stand alone" capability and shall maintain operator setpoints without connection to primary controllers or central station equipment. Modules shall be located at each operating equipment location such that individual systems or zones shall remain functional without communication to other systems on the network. Equipment operating logic, schedules and current trends shall reside in control modules serving each system. Use of global modules required to maintain programming, schedules or current trend data are not acceptable.

D. Ethernet Gateway Routers: System shall include an Ethernet Router/Gateway between the control module network and owners Ethernet. This gateway shall route BACnet communications between the control module network and the owners IP network. If the system is not to be connected to customer Ethernet the gateway shall be capable of connection via a web browser on the local host server.

E. Control Modules: Control modules shall include required inputs and outputs to meet sequence of operation and points list. Digital outputs shall be dry contact relays and analog outputs shall be industry standard 0-10 vdc, 2-10 vdc or 4-20 milli-amp. **Triac digital outputs are not**

acceptable. Modules shall be fully programmable for maximum system flexibility. **Application specific controllers are not acceptable.**

F. All modules shall have battery backup capable of maintaining all programs, setpoints, schedules and trend information for a minimum of 7 days.

G. All schedules and current trends shall be maintained in the individual control modules. The modules shall be capable of maintaining sufficient trend samples to report 24 hours of trend history in 5 minute increments for each input or output.

H. Temperature Sensors: Wall mounted zone temperature sensors shall be 10 k ohm thermistor. Zone sensors in primary occupied areas other than restrooms, hallways or storage rooms shall have setpoint adjustment to allow the occupants to raise or lower setpoint within operator defined paramenters. Additionally sensors in these primary areas shall have a push button to return the system to normal occupancy setpoints for an operator defined period. Exception will be common areas. Zone sensors for restrooms, hallways, storage rooms, gymnasiums, auditoriums and locker rooms shall be mounted on the back of an aluminum electrical box cover plate designed for zone sensing application. Gymnasium sensors shall also include a key access override feature.

I. All other temperature sensors shall be industry standard thermistor or 4-20 milli-amp. Immersion sensors shall be mounted in a blind well for future serviceability.

J. Valve and Damper Actuators: Actuators shall be manufactured by Belimo. Torque shall be rated for required load. Modulated actuator input shall be industry standard 0-10 vdc, 2-10 vdc, 4-20 milli-amp, floating motor (tri-state), or pulse width modulation. Two or three position operation is not acceptable for economizers, VAV dampers, multizone dampers, valves or any other application specifying modulated operation.

K. Dampers: Outside air control dampers shall have neoprene or vinyl-grip blade seals, stainless spring steel edge seals and a specified leakage rate of not more than 65 CFM/damper face area at 2” W.G. static pressure drop.

L. Wire: All wiring in open areas at heights below 12 feet must be run in conduit, otherwise control wiring may be run open in accessible ceiling or underfloor areas. Control wiring in non-accessible ceilings, walls or floors shall be in conduit. All wiring not in conduit or control cabinets shall be rated for plenum installation. Communication wiring shall be run in data cable tray whenever possible.

PART 4 - PRODUCT CAPABILITY SOFTWARE

A.. BACnet COMPATIBILITY

1. The system shall be fully native BACnet at the time of installation. This means that the system must use BACnet as the native communication protocol between distributed controllers communicating on the controller network (i.e. Field Bus) and must, as a minimum, support the following Objects and Application Services (Conformance Class 3):
2. Objects >Binary Input Services> Readproperty
   Binary Output Writeproperty
   Binary Value I-Am
   Analog Input I-Have
   Analog Output ReadMultiple Property
   Analog Value WriteMultiple Property

Calendar	Who-Has
Schedules	Who-Is

B. Programming for the system shall use BACnet objects and services. All BACnet objects and services shall be opened for read and/or read/write access during programming for future exposure to other BACnet systems. The front-end software for the system shall be able to query other third party BACnet points for read/write access.

C. MULTIPLE OPERATING PLATFORMS
   1. The front end server software furnished as a part of the DDC system shall be capable of operating on multiple operating systems such as Microsoft Windows, Linux or Sun Solaris.

D. GRAPHICAL PROGRAMMING
   1. The system shall be programmed using Eikon™ graphical programming language for ease of operator understanding. Operating sequences and logic flow shall be assembled in a schematic format using MicroBlocks representing inputs, outputs and logical functions such as setpoints, switches, limits, relays, PIDs etc. The programming software shall be furnished within this scope of work.
   2. Full simulation capability shall also be provided with the graphic programming. User shall be able to fully simulate the constructed sequence on screen before the sequences are downloaded into the controllers. The system shall also include the ability to simulate multiple graphic programs communicating with each other on a simulated network.

E. GRAPHICAL INTERFACE SOFTWARE
   1. System and Equipment Graphic User Interface: The operators interface software shall be developed using ViewBuilder™ graphical development software. Graphics display screens shall include a system level graphic of either a map of facilities or an elevation of the building, a graphic of each building floor plan and graphics for each operating system or unit within each building. Entry to the zone and equipment level interface graphics shall be through area maps and/or floor plans to facilitate user orientation. Additionally the system hierarchy shall be displayed in a fashion similar to Windows Explorer to enable the user to navigate to any graphical screen in the system by expanding building levels or floor levels and selecting a particular zone or system. Graphics shall be accessed by using a mouse or other pointer device. The system shall provide a visual indication of which building, floor and zone the user is accessing at any time. System shall be capable of changing all parameters and schedules, as well as downloading operating software from the same Graphical User Interface software program as that used for viewing system operation.
   2. Thermal graphic floor plans shall display each temperature zone in a color appropriate to current space temperature conditions. The system shall display in 8 separate colors the following conditions: High or low temperature alarm, temperature at setpoint, cooling call, heating call, more than 2° above setpoint, more than 2° below setpoint, unoccupied between setpoints and no communication. Floor plans shall also include color graphic indicators for non-zone specific mechanical equipment operation showing On/Off and Alarm Conditions. Status indication colors shall be updated dynamically as conditions change.
   3. Mechanical equipment pictorial graphics shall be displayed by the use of point-and-shoot selection using a mouse or other pointer device. Graphics shall be provided for all mechanical equipment and devices controlled by the DDC system. These graphics shall provide a current status of all I/O points being controlled and applicable to each piece of equipment including analog readouts in appropriate engineering units at appropriate locations on the graphic representation.
   4. Software Graphic Programming Live User Interface: The system shall be able to display the graphic displays of system programming, operating logic and logic flow with real time conditions displayed at each input, output and logical function. This display will allow the operator to observe each step of a control logic process and facilitate system software

troubleshooting. Operator shall have the ability to select any MircoBlock in the graphical program to change parameters including the ability to lock values.

F. FACILITY MANAGEMENT AND ENERGY MANAGEMENT FUNCTIONS
   1. Scheduling: The DDC system shall have the ability to schedule each individual zone, each building or floor or the entire network of buildings for any user with a single entry. Additionally the operator shall have the capability of assembling groups of zones, buildings or floors for single entry programming, e.g. several offices may be grouped for scheduling of Saturday operations. Available schedule types shall include normal operation, unoccupied operation, setback override and holidays. For maximum flexibility, schedules shall reside in the local control modules. Dated schedules shall be self managing and automatically delete after execution.
   2. Interactive Operations: The system shall have the ability to send run requests, heating requests and cooling requests from one module to another for the purpose of optimizing run operations of central plant equipment. Additionally the system shall be capable of limiting operation of various equipment if another mechanical point elsewhere in the system allows that operation. e.g. a boiler loop circulating pump shall run only when requested by a zone requiring heating operation and will shut down during hours that zone demand is satisfied.

G. ALARMS, TRENDS AND REPORTS
   1. System and Temperature Alarms: The system shall have the capability of monitoring conditions throughout the system and sending alarms or messages to an e-mail address, local PC or printer or to remote PC's, printers or to dial-up pagers. Alarms and messages shall be able to be prioritized for various levels of reporting and action. The operator shall have the ability to customize alarm text and messages.
   2. Trends: The system shall be capable of trending any input or output, or any logical point within the graphic program. There shall be no limitation to the number of points that can be trended at any particular time. Modules shall store in live memory 288 trend samples points for each trended item. The interval between trend samples shall be adjustable from 1 second to 24 hours. Trends from one or more modules shall be able to be simultaneously displayed on a single trend graph. Operator shall be able to "window" any segment of a trend to enlarge the view by dragging a mouse to form the "window". The system shall also have the ability of automatically downloading trend information from any module to the server or other computer connected to the network for historical trend storage. This trend information shall be able to be displayed on the trend graph along with live current trends in seamless fashion. Trend data collection requiring the use of a locally connected PC for data storage is unacceptable.
   3. Reports: The system shall be capable of generating reports of equipment run times, all trended points, temperature conditions, electric demand and usage and alarms or messages. The system shall also have the ability of automatically downloading report information from any module to the server or other computer connected to the network. The operator shall have the ability to create custom report and logging formats.

PART 5 - VAV ZONES AND SEQUENCE OF OPERATIONS

A. GENERAL
   1. The following sequences of operation shall be strictly observed. All temperature setpoints, static pressure setpoints, percentage of PID output trip points and reset ratios within this specification shall be changeable by operator using the operator software furnished with the system.

B. DISTRIBUTED CONTROL
   1. System shall observe the concept of distributed control. Modules shall be located at each operating equipment location such that individual systems or zones shall remain functional without communication to other systems on the network.

C. Central Plant, Pump and Fan Operation: Control of all central fan systems, chillers, boilers and pumping stations shall be based on run requests, heating requests or cooling requests from zone controls. Reset of supply air static pressure, supply air temperature, chilled water temperature and hot water temperature shall be based on zone temperature conditions and heating or cooling requests from zones.

D. Scheduling: For maximum flexibility all occupancy schedules shall be stored in zone control modules. Central fans or pumps shall start when commanded from any associated zones that call for occupancy or for operation to meet setback heating or cooling requirements and shall not require separate scheduling unless required for the sequence of operation. Fans or pumps shall run for minimum of 30 minutes.

5.1 VAV TERMINAL UNITS

A. Run Conditions

1. Zone shall have independent schedule capability. Scheduling shall be from a global schedule input, from local schedule or from a group schedule.
2. Outside air temperature shall be available from a global broadcast for local control options.
3. Demand level if provided in the project scope will be broadcast to this zone for set point offset or other demand control options.

B. Zone Setpoint Control

1. Zone sensor shall include set point adjustment and timed local override (optional) at the sensor.
    a. Set Point Adjust the occupant will be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.
    b. Timed local override control will allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit will automatically return to the schedule.
2. Zone set point control uses a modified Zone PID algorithm to provide a smooth modulated or staged variable for cooling and heating. When zone equipment has single stage on/off control such as a single stage compressor, the equipment will cycle on at preset PID output and off when PID output drops to a lower preset level from the PID.
3. Zone control shall alarm on high or low zone temperature. Zone Temperature alarms will be disabled during Optimal Start, 1st 30 minutes of scheduled occupancy or during Setback override.
4. Supply air temperature monitor shall be included and shall alarm on high or low supply air temperature differential from space temperature.

C. Night Purge Mode

1. Night Purge setpoints will be set by purge level from Global Night Purge Broadcast.
    a. Level 1 Night Purge cooling setpoint will be 69°F.
    b. Level 2 Night Purge cooling setpoint will be 67°F.
    c. Level 3 Night Purge cooling setpoint will be 65°F.
2. During Night Purge Mode OA or VAV dampers will not modulate, they will go to full open position until zone falls below cooling setpoint.
3. Night Purge heating setpoint will be offset down by 5°F until scheduled occupancy. On initiation of occupancy heating setpoint will be reset up 1°F every 30 minutes until occupied heating setpoint is reached. This is to prevent reheating a zone that has just night purged.
4. Night purge will begin when:
    a. A Night Purge Mode broadcast is received.
    b. Zone is 5 hours prior to occupancy.

c. Zone temperature is 1°F above night purge setpoint.

d. OA temperature is above 45°F and more than 10°F below zone temperature.

5. Night Purge Mode will end one hour prior to occupancy.

D. Cooling Control

1. When space temperature rises above cooling setpoint the zone setpoint control PID will modulate the variable air volume damper between the minimum ventilation air flow setpoint to maximum cooling air flow to maintain space cooling setpoint.
2. The fan will run during all heating and cooling operation.
3. If the space is requesting cooling and AHU supply air temperature exceeds zone temperature the VAV damper will close.

E. Heating Control w/Hot Water

1. When space temperature falls below heating setpoint the zone setpoint control PID will drive the variable air volume damper to auxiliary heating air flow setpoint.
2. The control will modulate the output to the HW valve between 0 and 100% as zone heating PID varies between 0 and 100%.
3. A second PID will Modulate the Air Flow Setpoint from Auxiliary Heating CFM Setpoint to Maximum Heating CFM Setpoint to maintain a maximum supply air setpoint of 90°F.
4. Heating will be locked out when outside air temperature is above 65°F.

F. Unoccupied Heating

1. When any one zone requests unoccupied heating, all zones associated with that AHU will activate unoccupied heating.
2. Fans will operate and all zones will heat to 5°F above their unoccupied heating setpoint before the AHU is no longer requested to run for unoccupied heating.

G. CO2 Control

1. If CO2 in the zone rises to 800 ppm a linear ratio output will modulate the damper between minimum cooling setpoint and maximum cooling setpoint as CO2 varies between 800 and 1000 ppm.
2. If zone temperature falls below heating setpoint during CO2 control operation, the zone re-heat will be enabled.

H. Communication between parent AHU and child Zone

1. The following network points will be read by parent AHU and sent by child Zone. These are the normal standard, but any value can be mapped to the parent AHU from the child Zone.

    a. Occupied Run time

    b. Unoccupied Run time

    c. Zone Cooling Percent

    d. Zone Heating Percent

    e. Zone Damper Position

    f. Night Flush request

    g. CO2 level

2. The following network points will be read by child Zone and sent by parent AHU. These are the normal standard, but any value can be mapped to the child Zone from the parent AHU.

    a. AHU Supply Air Temperature

    b. AHU Supply Static Pressure

I. Points

1. Zone Temperature
2. Discharge Air Temperature
3. Flow
4. Damper Output
5. Hot Water Valve

5.2 General Air Handler Sequences – Applies to all Non-Unitary AHUs

A. Run Conditions

1. System will operate based on requests from zone served by this unit. Outside air temperature from a LAN broadcast is available for control options. If demand control options are used, a LAN input is also available to receive building demand level. Optimal start is based on optimal start requests from the zones. Optimal stop will shut down the unit 5 minutes before the last VAV box goes into setback.

B. Safety Devices

1. Following Safeties will be wired in series with fan contactors/starters to shut down the Supply Fan and Return/Relief Fan when contact opening indicates an alarm condition.
2. Freeze Stat
    a. An auxiliary contact will be wired to a BAS module and will initiate the following:
        1) Redundant fans shutdown
        2) Close outside air/relief air/exhaust air dampers and open return air dampers
        3) Open hot water valves 100%
    b. Freeze stats require a manual reset at device as well as a software reset.
    c. An alarm will be sent whenever the Freeze Stat trips.
3. High Static Pressure Switch at supply fan discharge
    a. An auxiliary contact will be wired to a BAS module and will initiate redundant fans shutdown
    b. High Static Safeties require a manual reset at device as well as a software reset.
4. Local Fire/Smoke Alarm
    a. An auxiliary contact will be wired to an EMS module and will initiate redundant fans shutdown
5. All wired safeties will send an alarm to system frontend when enabled

C. Software Safety

1. The Supply Air Temperature sensor will monitor SAT and initiate a low temperature alarm when SAT falls below 42°F for more than 10 minutes while fan status is proven. This alarm requires software reset.

D. Points (To be determined by supplier/engineer)

5.3 Variable Air Volume Air Handling Units

A. Supply Fan Control

1. The supply fan will be continuously enabled whenever any zone is operating in an occupied mode and will cycle on zone demand for cooling to maintain unoccupied zone setpoints. If supply air flow from the AHU is required for unoccupied heating at the zones, the fan will cycle on demand for zone heating to maintain unoccupied zone heating setpoints.

2. Supply Fan VFD will modulate to maintain supply air static pressure setpoint.
3. Fan motor status will be monitored. If supply fan has been commanded to run by BAS and the fan status is not indicated, BAS will send an alarm to the operator workstation.

B. Return Fan Control

1. Return fan will run whenever supply fan has proven status.
2. Return fan VFD will follow supply fan speed multiplied by an offset multiplier to be established with the Test and Balancing Contractor.
3. Return fan motor status will be monitored. If return fan has been commanded to run by BAS and the fan status is not indicated, BAS system will send an alarm to the operator workstation.

C. Return Fan Control with Building Static Pressure Control

1. Return fan will run whenever supply fan has proven status.
2. Return fan VFD will follow supply fan speed with an offset based on return/outside air dampers position. As Return and Outside air dampers modulate more to outside air the return fan speed minimum shall decrease.
3. Building static pressure PID control shall override the above to increase return fan speed as needed to maintain building static setpoint of 0.03" w.c.
4. Return fan motor status will be monitored. If return fan has been commanded to run by BAS and the fan status is not indicated, BAS will send an alarm to the operator workstation.
5. Building static pressure high and low alarms are available if desired.

D. Supply Air Temperature Setpoint Reset

1. Occupied Mode
    a. The following SA temperature reset sequences will be enabled when two or more zone send Occupied Run Requests to the AHU
    b. SA Temperature Setpoint will be reset based on the zone cooling PIDs for all VAV zones served by that AHU
    c. Initial SAT Setpoint will be 75°F to prevent economizer cooling.
    d. When any zone's cooling PID demand rises above 10% the SA setpoint will be reset to 68°F.
    e. When any two zones reach 100% cooling demand the SAT setpoint will be reset down 1° F every five minutes. Minimum SA setpoint is 55° F.
    f. When only one zone PID is at 100% the setpoint will be held at the last reset setpoint.
    g. When all zone PIDs are below 100%, SA setpoint will be reset up 1° every five minutes until setpoint reaches 68°.
    h. If all zone PIDs fall below 10% SA setpoint will be reset to 75°.
    i. The zone cooling demand percent will be requested no less than every 3 minutes
2. Unoccupied Mode
    a. When all zones served by this AHU are unoccupied and a request for cooling is received from two or more zones SA cooling setpoint will be reset to 55°
    b. When all zones served by this AHU are unoccupied and a request for heating is received from any non-fan powered VAV box SA heating setpoint will be reset to 90°.
    c. Unoccupied Heating requests will take priority over cooling requests.

3. Morning Warm Up

    a. When Morning Warm Up request is received from two or more zones SA setpoint will be reset to 90° and cooling will be disabled.

    b. Morning Warm Up requests will take priority over cooling requests.

4. Night Purge

    a. When a Night Purge Request is received from any associated zone SA setpoint will be reset to 50°. Mechanical cooling will be disabled.

E. Supply Air Static Pressure Setpoint Reset

1. Static pressure setpoint will be established using trim and respond logic to increase or decrease setpoint input to a PI logic controller. The PI logic controller will modulate fan speed to maintain setpoint.
2. Initial static pressure setpoint will be 0.5" w.c.
3. Maximum static pressure setpoint (P-Max) will be determined as follows

    a. Set all VAV boxes to maximum occupied cfm.

        1) Set all VAV boxes to maximum air flow.

        2) Starting at 0.5" static pressure, adjust fan speed up until all boxes can maintain maximum occupied cfm.

        3) The pressure required for all boxes to maintain maximum air flow will be P-Max.

4. Reset between 0.5” and P-Max will be as follows:

    a. Whenever any 2 VAV boxes are 100% open, pressure setpoint will be increased by 0.05" w.c. every 5 minutes until the P-Max is met or only 1 VAV box is 100% open.

    b. If only one VAV box is at 100% pressure setpoint reset will be stopped and setpoint will remain at current setpoint.

    c. When all VAV boxes are reporting less than 100% open, the pressure setpoint will decrease by 0.05" every 5 minutes until setpoint is 0.5” or any individual VAV box again reaches 100% open.

F. Building Static Control with Relief Fan

1. Relief fan will be enabled when supply fan status is proven and building static is greater than 0.04” w.c. for more than 10 seconds.
2. Relief Fan VFD will be modulated by a PID control loop to maintain building static at 0.02” w.c.
3. If building static falls below 0.00” the relief fan will turn off.
4. Fan status shall be monitored and will alarm if fan is enabled by the control module and fan status is not verified.

G. Building Static Control w/Return Fan and Relief Damper Control (If applicable)

1. A static pressure sensor in the discharge of the return fan will provide input to a PI control loop to modulate the return fan speed to maintain .01” w.c. setpoint at the fan outlet.
2. A building space pressure sensor will provide input to a PI control loop to modulate the relief dampers to maintain a build static pressure setpoint of 0.03” w.c.
3. Fan status shall be monitored and will alarm if fan is enabled by the control module and fan status is not verified.
4. The return fan will not be allowed to run if both RA and RelA dampers are fully closed.
5. A high static pressure switch installed in the return fan discharge duct will trip the return fan if static pressure rises above 3.5” w.c.

H. Cooling Control – Staged DX

1. Mechanical Cooling will be enabled when the following conditions exist:
    a. Outside air temperature is greater than 62°F.
    b. Supply fan is commanded on
    c. Supply fan status is on
    d. Night Flush is not enabled
    e. Include interlock to lock out cooling whenever the emergency generator is running

2. SA Temperature input to the cooling PI controller will stage compressors based on percentage output to meet cooling SA setpoint. A SAT bias of +- 3°F of setpoint will hold PID to current value to prevent unnecessary cycling of DX. Bias disabled when Mechanical cooling is locked out)
3. When economizer cooling is unavailable compressors will stage as follows:
    a. 2 Stage Systems
        1) First stage on at 40% and off at 5%
        2) After 1st stage has been running for more than 5 minutes, second stage will be on at 80% and off at 35%
    b. 3 Stage Systems
        1) First stage on at 35% and off at 5%
        2) After 1st stage has been running for more than 5 minutes, second stage will be on at 60% and off at 30%
        3) After 2nd stage has been running for more than 5 minutes, third stage will be on at 95% and off at 55%
    c. 4 Stage Systems
        1) First stage on at 25% and off at 5%
        2) After 1st stage has been running for more than 5 minutes, second stage will be on at 50% and off at 20%
        3) After 2nd stage has been running for more than 5 minutes, third stage will be on at 75% and off at 45%
        4) Forth stage on at 95% and off at 70%
4. When economizer cooling is available compressors will stage as follows:
    a. 2 Stage Systems
        1) First stage on at 60% and off at 35%
        2) After 1st stage has been running for more than 5 minutes, second stage will be on at 95% and off at 55%
    b. 3 Stage Systems
        1) First stage on at 60% and off at 5%
        2) Second stage on at 80% and off at 55%
        3) After 2nd stage has been running for more than 5 minutes, third stage will be on at 95% and off at 75%
    c. 4 Stage Systems
        1) First stage on at 60% and off at 5%
        2) Second stage on at 75% and off at 55%

3) After 2nd stage has been running for more than 5 minutes, third stage will be on at 85% and off at 70%

4) Forth stage on at 95% and off at 80%

I. Cooling Control with Economizer and Optional DX cooling Control.

1. The intent is to allow load of the zones determine the number of stages of DX and minimize cycling of DX that would occur if a single SAT setpoint were used to stage DX as above.
2. When there are no zones requesting cooling operation SA cooling will be disabled.
3. When zones initiate a call for cooling and the OA temperature is below 62° the system shall modulate OA/RA and RelA dampers to maintain supply air temperature setpoint. Mechanical cooling will be disabled.
4. When the OA temperature is above 62° and more than 4° below RA temperature:
    a. The system will stage economizer and mechanical cooling to bring SA temperature below Max setpoint, initially 62°.
    b. Whenever SA falls below Max setpoint staging will stop until SA temperature rises above Max setpoint for more than 10 minutes, at which point an additional stage will initiate.
    c. If SA falls below 52° the system will begin to drop stages every 5 minutes until SA temperature rises above 52°.
    d. When SA temperature is above 52° and below Max setpoint, system will neither increase nor decrease the number of stages enabled.
    e. If system is below Max setpoint and any zone is unable to maintain zone temperature within 1° of cooling setpoint for more than 5 minutes, Max setpoint will be set 2° lower.
    f. Max temperature will not be reset below 58°.
5. When the OA temperature is less than 4° below RA temperature:
    a. Operation will be the same as above except that OA/RA and RelA dampers will return to maintain ventilation air position. Lead compressor solenoid valve will be first stage of cooling operation.
6. Compressor lead/lag will swap each day when system comes out of unoccupied operation.
7. Supply air low limit will close outside air dampers if SA falls below 42°F.
8. Economizer will close during unoccupied periods of operation; supply fan fails to prove status or freeze protection is active.
9. If mixed air temperature falls below 36°F for more than 5 minutes OA dampers will fully close and RA dampers will open. Fan and heating valve will continue to operate and an alarm will be generated.
10. If mixed air temperature remains below 36°F for an additional 5 minutes SA and RA fans will be disabled and HW valve will open to 100% open and an addition alarm will be generated.
11. CO2 Control
    a. CO2 sensor in the return air will provide input to a PI control loop to establish a variable low limit for the building ventilation air.
    b. When CO2 level is less than 800 ppm damper will remain in the minimum position.
    c. On rise of CO2 to 800 ppm the PI control loop output will modulate the output to the OA dampers and open OA to maintain 800 ppm until CO2 falls below 800 ppm.
    d. If CO2 reaches 1000ppm and alarm will be generated.
    e. If CO2 reaches 1500ppm or drops below 200ppm disable CO2 control and Alarm will

be generated.

f. Operator will have the ability to enable or disable CO2 control from the BAS.

J. Heating Control w/Hot Water

1. When space temperature falls below heating setpoint the zone setpoint control PID will drive the variable air volume damper to auxiliary heating air flow setpoint.
2. The control will modulate the output to the HW valve between 0 and 100% as zone heating PID varies between 0 and 100%.
3. A second PID will Modulate the Air Flow Setpoint from Auxiliary Heating CFM Setpoint to Maximum Heating CFM Setpoint to maintain a maximum supply air setpoint of 90°F.
4. Heating will be locked out when outside air temperature is above 65°F.

K. Economizer/Ventilation Control – Return Air CO2 monitor

1. Cooling Control
   a. Economizer Cooling will be enabled when the following conditions are met:
      1) Outside air temperature is more than 4° F below return air temperature
      2) Supply fan is commanded on
      3) Supply fan status is on
   b. Economizer will be controlled from the same PI control loop output as mechanical cooling.
   c. Cooling PID control output will modulate the Economizer to maintain SAT at SA setpoint.
   d. A mixed air low limit of 50°F will be maintained by a PID control loop.
   e. Economizer will be disabled when outside air temperature is less than 1° F below return air temperature. When disabled OA and RA dampers will be controlled by minimum air position as noted below.
   f. Supply air low limit will close outside air dampers if SA falls below 42°F.
   g. Economizer will close during unoccupied periods of operation; supply fan fails to prove status or freeze protection is active.
   h. If mixed air temperature falls below 36°F for more than 5 minutes OA dampers will fully close and RA dampers will open. Fan and heating valve will continue to operate and an alarm will be generated.
   i. If mixed air temperature remains below 36°F for an additional 5 minutes SA and RA fans will be disabled and HW valve will open to 100% open and an addition alarm will be generated.
2. CO2 Control
   a. CO2 sensor in the return air will provide input to a PI control loop to establish a variable low limit for the building ventilation air.
   b. When CO2 level is less than 800 ppm damper will remain in the minimum position.
   c. On rise of CO2 to 800 ppm the PI control loop output will modulate the output to the OA dampers and open OA to maintain 800 ppm until CO2 falls below 800 ppm.
   d. If CO2 reaches 1000ppm and alarm will be generated.
   e. If CO2 reaches 1500ppm or drops below 200ppm disable CO2 control and Alarm will be generated.

f. Operator will have the ability to enable or disable CO2 control from the EMS.

3. Minimum damper position

a. System will have a fixed absolute minimum damper position either set by the Test and Balance Contractor, or the required flow to offset normal building exhaust.

1) If there is not a TAB contractor, or if no minimum position is specified the following steps will be taken to determine minimum position.

a) Enable all exhaust fans that could normally be operational at any given time.

b) Measure static pressure differential between the building and outside air.

c) Set minimum position to establish pressure differential of 0.03” w.c.

L. Points (To be determined by supplier/engineer)

5.4 Hot Water System

A. Emergency Shut Down Switches

1. Emergency shutdown switches (if provided) located at each exit of the mechanical room will shut down Boiler(s) are hard wired to boilers and will shut down the boilers when depressed.

B. Heating Water Temperature Setpoint Reset Based on Outside Air Temperature

1. Heating Water Temperature Reset:

a. Heating water temperature shall be automatically reset based outside air temperature.

b. The heating water supply temperature setpoint shall reset downwards from 180°F (adjustable) to 120°F (adjustable).

Outside Air Temperature	**Hot Water Supply Temperature Setpoint**
< 20°F	180°F
> 20°F	180°F Linear Ramp to
< 60°F	120°F
> 60°F	120°F
> 60°F	120°F

C. Based on Unit (Zone) Demand Heating Water Temperature Setpoint Reset

1. Initially Loop Supply Temperature Setpoint will be set at 100°F to 150°F based on OAT between 55°F and 20°F at point of initial hot water system start.

2. A reset sequence will reset the initial setpoint based on demand from the requesting units.

a. When any two requesting units reach 100% heating demand the HWT setpoint will be reset up 2°F every five minutes to a maximum of 150°F.

b. If the total number of requesting units at 100% heating demand is less than two but greater than zero the current HWT setpoint will be held.

c. If the total number requesting units at 100% heating demand drops below one then HWT setpoint will be reset down 2°F every five minutes to minimum of 100°F.

3. The requesting units heating demand will be requested no less than every 3 minutes

4. Unoccupied Mode

a. If Hot Water Pumps run for freeze protection with no zone requesting heat, the HWT setpoint will be 100°F.

D. Hot Water Temperature Setpoint Reset Based on System Flow Demand

1. Hot water supply temperature setpoint will be generated by the BAS system and written to the manufacturer supplied boiler control panel via an analog output. The hot water supply temperature setpoint will be reset based on System Flow Demand MBH.

System Load	Hot Water Supply Temperature Setpoint
< 500 MBH	120°F
> 500 MBH	120°F Linear Ramp to
< 1500 MBH	150°F
> 1500 MBH	150°F

2. MBH = One Thousand BTU per hour.
    a. Calculation: MBH = [GPM X (HWST – HWRT) X 500] / 1000.

E. Boiler Hot Water Temperature Reset (load based)

1. Any zone or hot water utilizing device with a control valve will have included in its programming a ratio calculator that compares the valve open percentage to its listed flow (GPM) values for that device that will give an ending calculation of its percent of full load expressed as GPM utilization.
2. This resulting value will be broadcast to the boiler setpoint control logic.
3. Within the boiler setpoint control logic these GPM values will be totalized and compared to the hot water system total GPM value, and the resulting computation will be the total current load value that will in turn be used to calculate the hot water setpoint.
    a. Load = 0% of full system GPM, setpoint =160°F (adj.)
    b. Load > 75% of full system GPM, setpoint = 180°F (adj.)

F. Hot Water Pump Enable (Two Pump)

1. The lead hot water pump shall be enabled whenever:
    a. A definable number of hot water coils (Initially 1) with control valves over 10% open.
    b. For freeze protection anytime outside air temperature is less than 38°F (adj.).
2. To prevent short cycling, pump(s) shall run for a minimum time and be off for a minimum time (both user adjustable).
3. When Run is no longer commanded, the Enabled Boiler(s) will be disabled and after a 5 minute time delay the hot water pump(s) will be disabled.

G. Hot Water Pump Lead/Standby operation

1. Hot Water Pump Lead/Standby Operation:
    a. The two hot water pumps shall operate in a lead/standby fashion.
    b. The lead pump shall run first.
    c. On failure of the lead pump, the standby pump shall run and the lead pump shall turn off.
    d. The designated lead pump shall rotate upon one of the following conditions (user selectable):
        1) Manually through a software switch
        2) If pump runtime (adj.) has exceeded an initial value of 300hrs
        3) Daily
        4) Weekly
        5) Monthly

H. Lead Lag Operation

1. Hot Water Pump Lead/Lag operation
    a. When the lead pump is at 100% speed and pressure is less than setpoint, by preset

differential, for more than 5 minutes, the lag pump will be enabled.

b. When both pumps speed have reduced to less than 65% speed and setpoint is met for more than 1 minute, the lag pump will be disabled.

c. The final setpoints will be determined during commissioning to insure cycling of lag pump does not occur.

I. Hot Water Pump Speed

1. The Pump Speed is set via the heating loop differential pressure reverse acting PID controller. The heating loop differential pressure PID controller compares the heating loop differential pressure to the heating loop differential pressure setpoint and outputs a percent (0 to 100%) to control the pump VFD's. A Bias of 50% will be set to start the pumps initially at 30hz whenever system run command is given.
2. The acceleration / deceleration rate of the VFD shall be set to 180 seconds and adjusted to provide smooth transition when pumps sequence on and off.
3. When pumps are commanded to switch Lead Pump while pumps are running, the incoming lead pump will ramp up while the outgoing pump ramps down to minimize disturbance on the loop.

J. Boiler Control

1. Points (to be determined by supplier/engineer)
    a. Blr-1 Enable
    b. Blr-1 Circ Pump enable
    c. Blr-1 Circ Pump Status
    d. Blr-1 Alarm/Fault
    e. Blr 1 modulation (if Applicable)
    f. Blr-2 Enable
    g. Blr-2 Circ Pump enable
    h. Blr-2 Circ Pump Status
    i. Blr-2 Alarm/Fault
    j. Blr 2 modulation (if Applicable)
2. Boilers will come with manufacturer supplied operating limit switch and safeties.
3. Once either HWP is enabled and status is proven, the BAS will enable the boiler to operate on manufacturer installed controls.

K. Boiler Control with hot water reset

1. Boilers will come with manufacturer supplied operating limit switch and safeties.
2. Once either HWP is enabled and status is proven, the BAS will cycle the boiler to maintain hot water supply setpoint.
3. Once enabled, the boiler operates on manufacturer installed controls.

L. Night Purge

1. Boilers and hot water pumps will be disabled following a morning purge level 2 or 3.Alarms
2. Alarms shall be provided as follows:

    a. Boiler alarms as provided though Modbus by the boiler manufacturer in addition to:
        1) High hot water supply temperature.
        2) Low hot water supply temperature after system has been running for 30 minutes.

    b. Hot Water Pump 1
        1) Failure: Commanded on, but the status is off.
        2) Running in Hand: Commanded off, but the status is on.
        3) Runtime Exceeded: Status runtime exceeds a user definable limit.

    c. Hot Water Pump 2
        1) Failure: Commanded on, but the status is off.
        2) Running in Hand: Commanded off, but the status is on.
        3) Runtime Exceeded: Status runtime exceeds a user definable limit.
        4) Point list as follows

M. Boiler Enable (Two boilers)

1. Boilers will come with manufacturer supplied operating limit switch and safeties.
2. Once either HWP is enabled and status is proven, the lead boiler shall be enabled to maintain hot water supply setpoint.
3. Once enabled, the boiler shall operate on manufacturer installed controls.
4. To prevent short cycling, pump(s) shall run for a minimum time and be off for a minimum time (both user adjustable).
5. When Run is no longer commanded, the Enabled Boiler(s) will be disabled and after a 5-minute time delay the hot water pump(s) will be disabled.

N. Boiler Lead/Standby operation

1. Boiler Lead/Standby Operation:
    a. The two Boilers shall operate in a lead/standby fashion.
    b. The lead boiler shall run first.
    c. On failure of the lead boiler, the standby boiler shall run and the lead boiler shall turn off.
    d. The designated lead boiler shall rotate upon one of the following conditions (user selectable):
        1) Manually through a software switch
        2) If boiler runtime (adj.) has exceeded an initial value of 300hrs
        3) Daily
        4) Weekly
        5) Monthly

O. Lead Lag Operation

1. Boiler Lead/Lag operation
    a. When the lead boiler is enabled and steam pressure is less than setpoint for more than 5 minutes, the lag boiler will be enabled.
    b. When both boilers are enabled and steam pressure setpoint is met is met for more than 1 minute and boiler status on one or both boilers is off, the lag boiler will be disabled.
    c. The final setpoints will be determined during commissioning to insure cycling of lag boiler does not occur.

5.5 Exhaust Fan Control

A. Points

1. Exhaust Fan Enable
2. Exhaust Fan status

B. Run Conditions

1. The exhaust fan shall be enabled during scheduled occupancy.
2. Fan motor status will be monitored. If exhaust fan has been commanded to run by BAS and the fan status is not indicated, BAS will send an alarm to the operator workstation.

C. Dampers

1. Dampers are automatic Back Draft dampers and are not controlled or monitored by DDC. (To be determined)

END OF SECTION

HYDRONIC PIPING

SECTION 23 21 13

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. This Section includes piping, special-duty valves, makeup water for these systems; blowdown drain lines; and condensate drain piping.

1.3 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride.

B. PVC: Polyvinyl chloride.

1.4 SUBMITTALS

A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 23.

F. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with

the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

C To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

1.6 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for fire and smoke wall and floor assemblies.

1.7 EXTRA MATERIALS

A. Water Treatment Chemicals: Furnish sufficient chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Grooved Mechanical-Joint Fittings and Couplings:
   a. Central Sprinkler Company; Central Grooved Piping Products.
   b. Grinnell Mechanical Products.
   c. Victaulic Company of America.
2. Calibrated Balancing Valves:
   a. Armstrong Pumps, Inc.
   b. Flow Design, Inc.
   c. Gerand Engineering Company.
   d. Griswold Controls.
   e. ITT Bell & Gossett; ITT Fluid Technology Corp.
   f. Taco, Inc.
   g. Tour Andersson supplied by Victaulic
3. Pressure-Reducing Valves:
   a. Amtrol, Inc.

b. Armstrong Pumps, Inc.
c. Conbraco Industries, Inc.
d. ITT Bell & Gossett; ITT Fluid Technology Corp.
e. Spence Engineering Company, Inc.
f. Watts Industries, Inc.; Watts Regulators.

4. Safety Valves:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Conbraco Industries, Inc.
   d. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
   e. Kunkle Valve Division.
   f. Spence Engineering Company, Inc.
5. Automatic Flow-Control Valves:
   a. Flow Design, Inc.
   b. Griswold Controls.
6. Expansion Tanks:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. ITT Bell & Gossett; ITT Fluid Technology Corp.
   d. Taco, Inc.
7. Air Separators and Air Purgers:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. ITT Bell & Gossett; ITT Fluid Technology Corp.
   d. Taco, Inc.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22.

E. Wrought-Copper Unions: ASME B16.22.

F. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

G. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2 and Smaller: ASTM A 53, Type S (seamless) or Type F (furnace-butt welded), Grade B, Schedule 40, black steel, plain ends.

B. Steel Pipe, NPS 2-1/2 through NPS 12: ASTM A 53, Type E (electric-resistance welded), Grade B, Schedule 40, black steel, plain ends.

C. Steel Pipe, NPS 14 through NPS 18: ASTM A 53, Type E (electric-resistance welded) or

Type S (seamless), Grade B, Schedule 30, black steel, plain ends.

D. Steel Pipe, NPS 20: ASTM A 53, Type E (electric-resistance welded) or Type S (seamless), Grade B, Schedule 20, black steel, plain ends.

1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, Schedule 40, black steel; seamless for NPS 2 and smaller and electric-resistance welded for NPS 2-1/2 and larger.

E. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.

F. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

G. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

H. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

I. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

J. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   1. Material Group: 1.1.
   2. End Connections: Butt welding.
   3. Facings: Raised face.

K. Grooved Mechanical-Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47, Grade 32510 malleable iron; ASTM A 53, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders designed to accept grooved end couplings.

L. Standard Mechanical Couplings, 2 inch through 12 inch: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa).
   1. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.
      a. 2 inch through 12 inch: Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade EPDM compound designed for operating temperatures from -30 deg F to +250 deg F. Gasket temperature rating shall be met without the use of special lubricants.
   2. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source.
      a. 2” through 8”: Installation-ready flexible coupling for direct stab installation without field disassembly. Gasket shall be grade EPDM compound designed for operating temperatures from -30 deg F to +250 deg F. Gasket temperature rating shall be met without the use of special lubricants.

b. 10” through 12”: Standard flexible couplings. Gasket shall be Grade “E” EPDM compound designed for operating temperatures from -30 deg F to +230 deg F.

M. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

N. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

O. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.

P. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

Q. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.5 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F 441, Schedules 40 and 80, plain ends.

B. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends.

C. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.
1. CPVC Solvent Cement: ASTM F 493.

D. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.
1. PVC Solvent Cement: ASTM D 2564.

2.6 VALVES

A. Gate, globe, check, ball, and butterfly valves are specified in Division 23 Section "Valves."

B. Grooved-End Butterfly Valves
1. 2" through 12" Sizes: 300 psi CWP suitable for bidirectional and dead-end service at full rated pressure. Body shall be grooved end black enamel coated ductile iron conforming to ASTM A536. Disc shall be electroless nickel plated ductile iron with blowout proof 416 stainless steel stem. Disc shall be offset from the stem centerline to allow full 360 degree circumferential seating. Seat shall be pressure responsive EPDM. Valve bearings shall be TFE lined fiberglass, and stem seals shall be of the same grade elastomer as the valve seat. Valve shall be complete with ISO flange for actuation mounting. Valve operators shall be lever handle or gear operator, available with memory stop feature, locking

device, chainwheel, or supplied bare. (Valve with EPDM seat is UL classified in accordance with ANSI/NSF-61.)

C. Grooved-End Check Valves
   1. 2 inch through 12 inch sizes: Spring Assisted: Black enamel coated ductile iron body, ASTM A-536, Grade 65-45-12, elastomer encapsulated ductile iron disc suitable for intended service, stainless steel spring and shaft, welded-in nickel seat, 300 psi. Valve with pre-tapped ports as available option.

D. Refer to Part 3 "Valve Applications" Article for applications of each valve.

E. Calibrated Balancing Valves, NPS 2 and Smaller: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

F. Calibrated Balancing Valves, NPS 2-1/2 and Larger: Cast-iron or steel body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having flanged or grooved connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

G. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

H. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

I. Automatic Flow-Control Valves: Gray-iron body, factory set to maintain constant flow with plus or minus 5 percent over system pressure fluctuations, and equipped with a readout kit including flow meter, probes, hoses, flow charts, and carrying case. Each valve shall have an identification tag attached by chain, and be factory marked with the zone identification, valve number, and flow rate. Valve shall be line size and one of the following designs:
   1. Gray-iron or brass body, designed for 175 psig at 200 deg F with stainless-steel piston and spring.
   2. Brass or ferrous-metal body, designed for 300 psig at 250 deg F with corrosion-resistant, tamperproof, self-cleaning, piston-spring assembly easily removable for inspection or replacement.
   3. Combination assemblies, including bronze ball valve and brass alloy control valve, with stainless-steel piston and spring, fitted with pressure and temperature test valves, and designed for 300 psig at 250 deg F.

J. Plastic Ball Valves: 150-psig working pressure, 250 deg F maximum operating temperature, full port design, 1- or 2-piece body design, CPVC body and ball, polytetrafluoroethylene seats, EPDM seals, and tee handle; with threaded, socket, union, or flanged connections.

K. Plastic Butterfly Valves: 150-psig working pressure, 250 deg F maximum operating temperature, PVC wafer body, polytetrafluoroethylene seats, lever lock handle, and wafer style for installation between flanges.

2.7 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection.

C. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. Include the following fittings and accessories:
   1. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Design tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
   2. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; designed to admit air to compression tank, drain water, and close off system.
   3. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.

D. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity by a flexible bladder securely sealed into tank. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

E. Tangential-Type Air Separators: Welded black steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature; perforated stainless-steel air collector tube designed to direct released air into expansion tank; tangential inlet and outlet connections; threaded connections for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger; threaded blowdown connection. Provide units in sizes for full-system flow capacity.

F. In-Line Air Separators: One-piece cast iron with an integral weir designed to decelerate system flow to maximize air separation at a working pressure up to 175 psig and liquid temperature up to 300 deg F.

G. Air Purgers: Cast-iron body with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal. Maximum working pressure of 150 psig and temperature of 250 deg F.

H. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
   1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

I. Diverting Fittings: 125-psig working pressure; 250 deg F maximum operating temperature; cast-iron body with threaded ends, or wrought copper with soldered ends.

Indicate flow direction on fitting.

J. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.

K. Grooved Y-Pattern Strainer: 2 inch through 18 inch sizes, 300 PSI Y-Type Strainer shall consist of ductile iron body, ASTM A-536, Grade 65-45-12, Type 304 stainless steel perforated metal removable baskets with 1/16" (1,6mm) diameter perforations 2"-3" strainer sizes, 1/8" (3,2mm) diameter perforations 4"-12" strainer sizes, and 0.156" (4mm) diameter perforations 14" -18" strainer sizes. Strainer basket shall be accessed by removal of mechanical coupling.

L. Basket Strainers: 125-psig working pressure; high-tensile cast-iron body (ASTM A 126, Class B), flanged-end connections, bolted cover, perforated stainless-steel basket, and bottom drain connection.

M. T-Pattern Strainers: 750-psig working pressure; ductile-iron or malleable-iron body, grooved-end connections, stainless-steel basket with 57 percent free area; removable access coupling and end cap for strainer maintenance.

N. Grooved T-Pattern Strainer: 2" through 12" sizes, 300 PSI T-Type Strainer shall consist of ductile iron (ASTM A-536, Grade 65-45-12) body, Type 304 stainless steel frame and mesh removable basket with No. 12 mesh, 2"-3" strainer sizes, or No. 6 mesh, 4"-12" strainer sizes, 57% free open area. Strainer basket shall be accessed by removal of mechanical coupling.

O. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged- or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

P. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

Q. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Heat Pump Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints or Schedule 40 steel pipe with threaded joints. Belowground or within slabs, use Type K annealed-temper copper tubing with soldered joints. Use the fewest possible joints belowground and within floor slabs.

B. Heat Pump Water, NPS 2-1/2 and Larger: Schedule 40 steel pipe with welded and flanged joints.

C. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints or Schedule 40, PVC pipe with solvent-welded joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
   1. Shutoff Duty: Gate, ball, and butterfly valves.
   2. Throttling Duty: Globe, ball, and butterfly valves.

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

C. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

A. Refer to Division 23 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

E. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

F. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

G. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Anchor piping for proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and

Supports." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
   2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer. cal runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Division 23 Section "Basic Mechanical Materials and Methods" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC and CPVC piping.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents in mechanical equipment rooms only at high points of system piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. Install dip-tube fittings in boiler outlet. Install piping to expansion tank with a 2 percent upward slope toward tank. Connect boiler-outlet piping.

D. Install in-line air separators in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install drain valve on units NPS 2 and larger.

E. Install combination air separator and strainer in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install blowdown piping with gate valve; extend to nearest drain.

F. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above floor. Install feeder in bypass line, off main, using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

G. Install expansion tanks above air separator. Install gage glass and cocks on end of tank. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
   1. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, and fittings, plus weight of a full tank of water. Do not overload building components and structural members.

H. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If multiple, parallel control

valves are installed, only one bypass is required.

D. Install ports for pressure and temperature gages at coil inlet connections.

3.8 CHEMICAL TREATMENT

A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

B. Fill system and perform initial chemical treatment.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Flush system with clean water. Clean strainers.
   4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
   5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
   6. Grooved pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.
   7. The grooved couplings gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.
   8. Grooved couplings installation shall be complete when visual metal-to-metal contact is reached.

3.10 GROOVED PIPING TRAINING

A. A factory trained representative (direct employee) of the grooved coupling supplier shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation.

PART 4 - Testing

A. Perform the following tests on hydronic piping:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
   3. Check expansion tanks to determine that they are not air bound and that system is full of water.
   4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of

specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

4.1 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
8. Lubricate motors and bearings.

4.2 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION

HOT WATER HEATING SYSTEM

SECTION 23 21 15

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install system of supply and return piping, boiler water make-up lines, and boiler drain lines as described in Contract Documents.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ends of all pipe shall be reamed out before being made up into fittings.

B. Use graphite and oil applied to male threads only in making up all pipe joint fittings.

C. Install unions on downstream side of shut-off valves and specialty valves and meters. Also install unions on both ends of radiation piping where piping goes from floor level into steel pipe troughs in floor slab.

D. Use teflon tape for lubricating threads on all threaded connections.

3.2 PIPING GRADE

A. Heating supply and return lines are to be graded up 1 inch to 40 feet, in the direction of flow with the high and low points in every case being in the boiler room to permit drainage.

B. Provide an automatic air eliminator at the high of each circuit and on the heating coils.

C. If it is necessary to change the grade of a flow main due to an obstruction, the high point shall be vented with an automatic air vent.

D. All runouts shall be taken off the top of the main and at least three elbow joints used on the spring piece to provide for expansion and contraction.

3.3 CLEANING SYSTEM

A. Thoroughly clean all equipment, piping and all other material controlled under this contract free from rust, scale, and other dirt before any painting or covering is done or the system is put into operation.

B. The heating system shall be thoroughly cleaned by operating at 10 psi for at least 6 hours.

1. At end of run, the boiler is to be filled to the top with water and any film of oil or grease is to be washed over the top.
2. Drain the boiler completely and refill to proper level with fresh water.
3. Repeat this process three (3) times.
4. Use 1 pound tri-sodium phosphate for every 100 gallons of water during cleaning operation.

3.4 FIELD QUALITY CONTROL

A. Piping systems shall be subjected to the following tests and no piping shall be covered or concealed until it has been so tested, inspected, and approved by the Architect and any local inspector having jurisdiction.
   1. Heating piping shall be hydrostatically tested at 50 psi in excess of maximum working pressures, 100 psi minimum.
   2. Without connecting equipment items rated below 100 psi, pressure test system at 100 psi for two hours. Correct leaks and defective work and repeat test until no leaks appear.
   3. When so directed by Architect or Engineer, the Contractor shall conduct an operating test on any piece of equipment to demonstrate its capacity and/or operating characteristics.

END OF SECTION

HOT WATER HEATING SYSTEM SPECIALTIES

SECTION 23 21 16

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install hot water heating specialties as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUAL AIR VALVES

A. On each coil or piece of equipment wherever an air pocket can form.

B. On each high point of piping or as shown on plans.

C. Approved Manufacturers:
   1. Hoffman #500 or equal complete with #550 air chamber.

2.2 AUTOMATIC AIR ELIMINATORS

A. Furnish and install at the high point of each zone piping, or wherever an air pocket can form because of obstructions in the piping, a 3/4" float operated automatic air eliminator, Hoffman #79.

2.3 BALANCING FITTINGS

A. Automatic flow regulator kits complete with ball valve and strainer with capacity shown. Provide P/T test valves.
   1. Approved Manufacturers:
      a. Griswold
      b. Auto flow

B. Manual balance valves with capacity shown. Provide with PT gage taps.
   1. Approved Manufacturers:
      a. Bell & Gossett circuit setters
      b. Armstrong

2.4 COMPRESSION TANKS

A. Welded steel compression tanks of sizes shown, ASME Code for 30 lb. W.P., made of steel plate.

B. Provide a water column with water gauge and gauge cocks on ends of tanks.

C. Tanks to be furnished with three 3/4 inch I.P.S. female thread connections, one at either end and one in the middle.

D. Approved Manufacturers
   1. B&G

2.5 AIR SEPARATORS

A. Furnish and install as shown on plans, air separator with tangential nozzles. The air separator shall be fitted with an NPT vent connection to facilitate installation of piping to connect a compression tank.

B. An NPT tapping shall be provided on the bottom of the air separator to facilitate blowdown.

C. The air separator shall also be equipped with a steel system strainer with a free area of not less than four times the cross sectional area of the connecting piping.

D. Air separators shall be fabricated steel with flanged connections, designed and constricted for 165 psig @ 375°F, and in accordance with Section VIII Division I of ASME Boiler & Pressure Vessel Code.

E. Approved Manufacturers
   1. B&G Rollairtrol
   2. Armstrong VAS

2.6 PRESSURE GAUGES

A. Cases shall be black enameled cast aluminum with back flange for surface or line mounting.

B. Gauges shall be of the repairable type with sturdy brass movements and phosphor bronze tubes.

C. Range shall be selected so that normal operating pressure shall be approximately at the center of the dial.

D. 3-1/2 inch figure bourdon tube type pressure gauge.

E. Install on inlet of each pressure gauge a No. 38, 1/4 inch consolidated brass "T" handle gauge cock.

F. Approved Manufacturers:
   1. U. S. Gauge
   2. Trerice

2.7 BOILER FITTINGS & COMPRESSION TANK FITTINGS

A. Boiler fittings as detailed on plans.
   1. Approved Manufacturers:
      a. Bell & Gossett Airtrol

B. Compression Tank Fittings:
   1. Install according to detail and manufacturer's instructions.
   2. Fitted for diameter tanks shown.
   3. Tank fittings to be connected with 1 inch black pipes pitched up to tanks.
   4. Compression tanks fitted with 3/4 inch drain piped to floor of boiler room to permit draining of tanks.
   5. Approved Manufacturers:

a. Bell & Gossett ATFL Airtrol

2.8 SELF-FILLING VALVES

A. 3/4 inch reducing valves (self-filling)

B. Brass body and bronze interior

C. Install on water service to boiler.

D. Approved Manufacturers:
1. Bell & Gossett No. 12
2. Or equal

2.9 BOILER RELIEF VALVE

A. ASME Code relief valve.

B. Approved Manufacturers:
1. Bell & Gossett
2. Or Equal

2.10 THERMOMETERS AND ACCESSORIES

A. Red reading, mercury, separable socket, 7 inch cast, adjustable with 3 1/2 inch stem.

B. Range: Heating 30 degrees to 240 degrees F.

C. Provide other accessories as shown.

D. Approved Manufacturers:
1. Weiss
2. Trerice
3. Palmer

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pressure gauges on each side of each pump and elsewhere as shown on plans.

B. Install "T" handle gauge cock on the inlet of each pressure gauge.

END OF SECTION

BACKFLOW PREVENTER VALVE

SECTION 23 21 18

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install a backflow preventer valve as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Designed to provide separation of radiant hot water heating system water from domestic cold water supply in accordance with Code.
   1. Rated flow at 30 psi pressure drop rated for 175 psi inlet pressure and 140 deg. F maximum operating temperature.
   2. Brass body construction with 3/4 inch NPT connections.

B. Approved Manufacturers:
   1. Beeco 12
   2. Watts 900
   3. Equal by Febco
   4. Equal by Conbraco

PART 3 - EXECUTION

3.1 INSTALLATION

A. Furnish and install a drain cup and pipe the waste line to the nearest floor drain or floor sink.

END OF SECTION

CIRCULATING PUMPS AND ACCESSORIES

SECTION 23 21 23

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 22 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install circulating water pumps and accessories as described in the Contract Documents.

PART 2 - PRODUCTS

2.1 TRIPLE DUTY VALVES

A. Place on each pump discharge. Valve serves as a non-slam check valve with spring loaded disk check, calibrated adjustable and lockable balance valve and full shutoff valve with memory stop. Valve shall be back-seated so as to allow repacking under full line pressure.

B. Cast iron body

C. Bronze disk and seat with stainless steel stems and springs.

D. Teflon packing

E. Maximum valve working pressure of 175 psig and a maximum operating temperature of 300 deg. F.

F. Approved Manufacturers:
1. Bell & Gossett
2. Armstrong

2.2 EXPANSION JOINT PUMP CONNECTORS

A. Precision machine molded neoprene and nylon construction internal reinforced by means of steel wire.

B. Cadmium steel floating flanges tapped to mate with 150# ASA companion flanges.

C. Capable of operating at a temperature of 20 deg. F. thru 220 deg. F. and at a pressure ranging from 10" HG vacuum thru 150 psi working pressure.

D. Capable of 15 deg. angular deflection.

E. Twin quiet-sphere design with control rods.

F. Approved Manufacturers:
1. Vibration Mountings & Controls, Inc.
2. Metraflex

2.3 IN-LINE CIRCULATORS

A. Bronze fitted with ceramic seal, spring coupling, and 1750-rpm, drip-proof motor with overload protection.

B. Substantially supported in piping with a full size leg to floor.

C. Approved Manufacturers:
   1. Bell & Gossett
   2. Armstrong
   3. Grundfos
   4. Or Approved Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturers instructions.

B. Align pump and motor shafts in accordance with manufacturers requirements before starting equipment. Provide report in the M&O manual regarding pump alignment.

C. Remove start-up filter screen on suction diffuser after system has been cleaned and flushed. Leave main filter screen in place.

END OF SECTION

CLEANING AND FLUSHING WATER CIRCULATING SYSTEMS

SECTION 23 21 25

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish labor and materials to thoroughly clean water circulating systems as described in Contract Documents.

B. Mechanical contractor shall procure the services of an independent treatment contractor as described in this specification.

1.3 QUALITY ASSURANCE

A. System Additives: This Contractor shall not add any water treatment chemicals or "stop-leak" compounds to the system.

PART 2 - EXECUTION

2.1 FIELD QUALITY ASSURANCE

A. Water circulating systems for project shall be thoroughly cleaned before placing in operation to rid system of dirt, piping compound, mill scale, oil, and other materials foreign to water being circulated.

B. During construction extreme care shall be exercised to prevent dirt and other foreign matter from entering pipe or other parts of system. Pipe stored on project shall have open ends capped and equipment shall have openings fully protected. Before erection, each piece of pipe, fittings, or valve shall be visually examined and dirt removed.

C. Side Stream Filtration and Flushing Valves
1. The Mechanical Contractor shall install a bag style side stream filter in the main mechanical room. This filter shall be furnished with 12 clean polyester bags with a filtration rating of 5 micron. The filter shall be sized to provide a pressure drop equal to the pressure drop of the parallel component with 80% flow through the primary component and 20% through the filter. Minimum filter size shall be 18” high and 6” in diameter. If this minimum size allows excessive flow through the side stream filter a balance valve shall be installed to insure sufficient flow through the primary central plant component.
2. Ball valves of full line size shall be installed at the end of each primary run. The valves shall have a nipple and cap installed.

D. Hydronic Closed Loop Cleaning
1. Prior to any introduction of fluids to the closed loop system the Mechanical Contractor shall close isolation valves at each heat pump and open the bypass valve to prevent flow through the strainer, flow control device and heat pump during the initial flushing and subsequent cleaning. The side stream filter bag shall be removed during the initial flushing process.

2. The Mechanical Contractor shall fill each hydronic system with clean fresh water prior to cleaning and thoroughly leak check system piping. A cleaning and passivating agent supplied by the Chemical Treatment Contractor shall be added to the system at the direction of the Treatment Contractor during the leak check process to minimize initial corrosion. If the system is filled multiple times during the leak check and repair process the Mechanical Contractor shall coordinate with the Treatment Contractor to maintain this initial protection. The Treatment Contractor is responsible for providing chemical for up to two refills of the system. If additional chemical is required due to multiple refillings the Mechanical Contractor shall be responsible for the additional time and chemical.
3. Following leak check the closed system shall be flushed by the Mechanical Contractor until the leaving water runs clear. All primary runs shall be flushed at their ends to obtain maximum sweep of debris from the system. The inlet screens on the circulating pumps must be kept clear during this initial cleaning process and inspected following cleaning. When flushing is complete the system is to be left full.
4. Prior to flushing the Mechanical Contractor shall coordinate with Treatment Contractor so that the Treatment Contractor can be available immediately following flush and final refill to add cleaning chemical within 4 hours to prevent initial corrosion.
5. Following initial flushing the Chemical Treatment Contractor shall refill all systems with cleaning and passivating agents raising the PH to a minimum of 10, circulate and flush until thoroughly clean. All primary piping runs shall be flushed at the ends during this cleaning process. When boiler operation is available the loop temperature should be raised to 110 to 120° to accelerate cleaning. Cleaning with availability of boiler operation should be anticipated to last 7 to 10 days or longer depending on initial loop conditions. If boiler operation is unavailable loop cleaning duration should be expected to double. The Chemical Treatment Contractor shall verify and adjust cleaning chemistry, and inspect side stream filter bags at a minimum of every two days, exception for weekends. Filter bags shall be changed as required during this cleaning process. Cleaning shall continue until these bags no longer show signs of debris.
6. Following cleaning process the Treatment Contractor shall close the bypass valves at each heat pump and open isolation valves for normal operation and check for leaks of local piping connections. Any leaks found shall be referred to the Mechanical Contractor for repair. The bypass valve handle shall be removed and tied to the valve. The system shall then be charged with final operating chemical to control long term corrosion and a clean bag filter shall be installed in the system.
7. The Treatment Contractor shall provide final inspection report for inclusion in the Operation and Maintenance Manual. Additionally the Treatment Contractor shall take loop samples approximately 12 months following completion, add or adjust chemical as required and provide a post construction report to the owner prior to warranty closeout. Chemical required is the responsibility of the Treatment Contractor.

E. Fluid Cooler Chemical Treatment Station

1. A chemical treatment station shall be provided by the Treatment Contractor in a 24” x 24” locked cabinet. Station shall include LMI DC4000-1-1 conductivity meter with sensor and A-17-1-1351S chemical pump, or approved equal. The chemical station shall be located inside the mechanical room. Mechanical Contractor shall provide ¾” PVC piping from the discharge of the spray pump of the fluid cooler to the station enclosure with T’s for installation of the conductivity sensor and for chemical injection. This contractor shall also provide return piping back to the fluid cooler sump at the opposite end from the spray pump pickup.

The Treatment Contractor shall install the conductivity sensor and injection fitting in the T's provided and set up initial treatment.

2. Under the scope of this specification the Treatment Contractor shall monitor the tower sump and adjust feed and bleed to maintain proper control of scale and corrosion for a period of one year. At a minimum tower treatment shall be check monthly from May until October. The Treatment Contractor shall provide all chemical required during the first year of operation

END OF SECTION

SPLIT SYSTEM HEAT PUMP UNITS

SECTION 23 21 66

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To
   1. Furnish and install heat pumps as described in Contract Documents.

B. Related Sections
   1. Section 02776 - Concrete pads
   2. Section 23 0501 - Common HVAC Requirements

1.2 SUBMITTALS

A. Quality Assurance / Control - Equipment check-out sheets

1.3 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies - Each unit shall be UL or ETL labeled.

1.4 WARRANTY

A. Provide five year warranty on compressors beginning from date of start-up. Record start-up date on warranty certificate for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Heat Pumps
   1. Indoor Units -
      a. Compact wall mounted units.
      b. Supplementary electric heater, size as scheduled.
      c. Cabinet finish as selected by Architect.
      d. Isolate moving parts from cabinets to reduce noise.
   2. Outdoor Units -
      a. Compressor shall be of rotary or scroll design.
      b. Fans shall be direct driven and discharge horizontally.
      c. Casing shall be fully weatherproof for outdoor installations.
      d. Microprocessor Controls shall be factory wired with field installed remote pendant station.
      e. Refrigerant shall be R-410A.
      f. Isolate moving parts from cabinets to reduce noise.
      g. Use dry-charged tubing for connection of unit's refrigerant system.
   3. Approved Products -
      a. Carrier Corp, Syracuse, NY (800) 227-7437 or (315) 432-6000 www.carrier-commercial.com
      b. Friedrich Air Conditioning Co, Austin, TX (800) 541-6645 or (210) 225-2000 www.friedrich.com
      c. Mitsubishi Electronics America Inc, HVAC Div, Norcross, GA (800) 421-1140 or (770) 448-1268

d. Sanyo Air Conditioning Products, Chatsworth, CA (818) 998-7322 www.sanyo.com
e. L.G. Electronics, USA, Englewood Cliffs, NJ (201) 585-0018, www.lghvac.com

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Manufacturer's Field Service - Units shall be started up, checked out, and adjusted by Unit Manufacturer's authorized factory trained service mechanic. Use equipment check-out sheet provided by Manufacturer. Complete and sign all items on sheet.

END OF SECTION

CHEMICAL WATER TREATMENT

SECTION 23 25 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Procure services of Water Treatment Service Organization which will:
   1. Furnish and install required chemical feeding equipment and perform other related services as described in Contract Documents.
   2. Perform initial cleaning and flushing procedures.
   3. Provide chemicals required for cleaning and flushing systems.

B. Related Work Specified Elsewhere:
   1. Owner will supply operating chemicals after start-up chemicals have been exhausted.

1.3 SUBMITTALS

A. Quality Control:
   1. Submit written recommended treatment procedures, chemicals, chemical feeding equipment, and basic water analyses test equipment, based on its experience and chemical analysis of representative sample of water supply.

1.4 MAINTENANCE

A. Test Equipment:
   1. Provide water analysis test kit and adequate supply of reagents suitable to control treatment chemical dosage requirements.

PART 2 - PRODUCTS

2.1 HOT WATER SYSTEMS

A. Two Gallon bypass feeder complete, including piping, valves, and accessories.
   1. Provide adequate supply of Dearborn Aqua-Serv B-547 liquid borate-nitrite based corrosion inhibitor.

B. Approved Manufacturers:
   1. M. A. Fleckenstein
   2. Neptune
   3. Wingert

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide initial start up and adjustment of all chemical systems.

B. Provide instruction to owner in the use and operation of the test kit.

C. Provide (2) two additional trips to the site during the warrantee period to check and adjust the chemical treatment system.

END OF SECTION

LOW-PRESSURE STEEL DUCTWORK

SECTION 23 31 14

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install above-grade ductwork and related items as described in Contract Documents.

PART 2 - PRODUCTS

2.1 DUCTS

A. Fabricate of zinc-coated lockforming quality steel sheets meeting requirements of ASTM 653A/653M, "Specification for Sheet Steel Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality", with G 60 coating.

B. Use of aluminum, non-metallic, or round ducts is not permitted. [Specification writer: Use of aluminum ducts in areas with high chlorine content (eg.: ventilation for pools, spas, etc.) should be considered on a per job basis.]

2.2 DUCT JOINTS

A. Ducts with sides up to and including 36 inches shall be as detailed in the SMACNA manual.

B. Duct sizes over 36 inches shall be fabricated using SMACNA T-24 flange joints or pre-fabricated systems as follows:
   1. Ducts with sides over 36 inches to 48 inches:
      a. transverse duct joint system by Ductmate/25, Nexus, Ward, or WDCI (Lite) (SMACNA "E" or "G" Type connection).
   2. Ducts 48 inches & larger:
      a. Ductmate/35, Nexus, or WDCI (Heavy) (SMACNA "J" Type connection).
   3. Approved Manufacturers:
      a. Ductmate Industries Inc, 10760 Bay Meadows Drive, Sandy, UT 84092 (801) 571-5308
      b. Nexus, Exanno Corp, P O Box 729, Buffalo, NY 14206 (716) 849-0545
      c. Ward Industries Inc, 1661 Lebanon Church Road, Pittsburg, PA 15236 (800) 466-9374
      d. WDCI, P O Box 10868, Pittsburg, PA 15236 (800) 245-3188

2.3 ACCESS DOORS IN DUCTS

A. At each manual outside air damper and at each motorized damper, install factory built insulated access door with hinges and sash locks. Locate doors within 6 inches of installed dampers. Construction shall be galvanized sheet metal, 24 ga minimum.

B. Fire and smoke damper access doors shall have a minimum clear opening of 12" x 12"

or as specified on Drawings to easily service fire or smoke damper. Doors shall be within 6 inches of fire and smoke dampers and in Mechanical Room if possible.

C. Identify each door with 1/2" high letters reading “smoke damper” or “fire damper”.

D. Approved Manufacturers:
1. AirBalance - Fire/Seal #FSA 100
2. Air Control Products - HAD-10
3. Cesco-Advanced Air - HAD-10
4. Elgen - Model 85 A
5. Kees Inc - ADH-D.
6. Louvers & Dampers - #SMD-G-F
7. Nailor-Hart Industries Inc - Series 0831
8. National Controlled Air Inc - Model AD-FL-1

2.4 FLEXIBLE EQUIPMENT CONNECTIONS

A. 30 oz closely woven UL approved glass fabric, double coated with neoprene.

B. Fire retardant, waterproof, air-tight, resistant to acids and grease, and withstand constant temperatures of 250 deg F.

C. Approved Manufacturers:
1. Cain - N-100
2. Duro Dyne - MFN
3. Elgen - ZLN
4. Ventfabrics - Ventglas

2.5 CONCEALED CEILING DAMPER REGULATORS

A. Approved Manufacturers:
1. Cain
2. Duro Dyne
3. Metco Inc
4. Vent-Lock - #666
5. Young - #303

2.6 VOLUME DAMPERS

A. In Main Ducts:
1. 16 gauge galvanized steel, opposed blade type with 3/8 inch pins and end bearings. Blades shall have 1/8 inch clearance all around.
2. Damper shall operate within acoustical duct liner.
3. Provide channel spacer equal to thickness of duct liner.
4. Approved Manufacturers:
   a. Air Balance - Model AC-2
   b. Air Control Products - CD-OB
   c. American Warming - VC-2-AA
   d. Greenheck - VCD-1100
   e. NCA, Safe Air
   f. Vent Products - 5100

B. In Sheet Metal Branch Ducts:
1. Extruded aluminum, opposed blade type. When in open position, shall not extend beyond damper frame.

2. Maximum blade length 12 inches.
3. Damper Regulator shall be concealed type with operation from bottom or with 90 deg miter gear assembly from side.
4. Approved Manufacturers:
   a. Air Control Products - TCD-OB
   b. Air Guide - OB
   c. Arrow - OBDAF-207
   d. CESCO - CDA
   e. Reliable Metals - OBD-RO
   f. Tuttle & Bailey - A7RDDM
   g. Safe Air
   h. Young - 820-AC

C. Dampers above removable ceiling and in Mechanical Rooms shall have locking quadrant on bottom or side of duct. Otherwise, provide concealed ceiling damper regulator and cover plate.

2.7 MOTORIZED OUTSIDE AIR DAMPERS

A. Damper Blades:
1. 18 gauge galvanized steel or equivalent aluminum with replaceable rubber blade edges, 9 inches wide maximum.
2. End seals shall be flexible metal compression type.
3. Opposed blade type.

B. Make provision for damper actuators and actuator linkages to be mounted external of air flow.

C. Approved Manufacturers & Models:
1. Air Balance - AC-2
2. American Warming - VC-2-AAVA
3. Arrow - OBDAF-207
4. Greenheck - VCD-2100
5. Honeywell - D641
6. Johnson - D1300
7. Louvers & Dampers - TSD400
8. Ruskin - CD36 or CD60
9. Safe Air - 610
10. Vent Products - 5800

2.8 BACKDRAFT DAMPER

A. Backdraft blades shall be nonmetallic and shall be neoprene coated fiberglass.

B. Stop shall be galvanized steel screen or expanded metal, 1/2 inch mesh.

C. Frame shall be galvanized steel or extruded aluminum alloy.

D. Approved Models & Manufacturers:
1. Air Control Products - FBD
2. American Warming - BD-15
3. CESCO - FBD 101
4. Ruskin - NMS2
5. Safe Air

2.9 DUCT HANGERS

A. 1" x 18 gauge galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 8 feet apart. Do not use wire hangers.

B. Attaching screws at trusses shall be 1-1/2 inch No. 10 round head wood screws. Nails not allowed.

2.10 DUCT SEALER

A. Cain - Duct Butter or Butter Tak

B. Design Polymerics - DP 1010

C. DSC - Stretch Coat

D. Duro Dyne - S2

E. Hardcast - #601 Iron-Grip or Peel-N-Seal Tape
1. Kingco - 15-325
2. Mon-Eco - 44-41
3. Trans-Continental Equipment Co - Multipurpose Duct Sealant
4. United - Sheet Metal duct-sealer

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ducts:
1. Straight and smooth on inside with joints neatly finished unless otherwise directed.
2. Duct panels through 48 inch dimension having acoustic duct liner need not be crossbroken or beaded.
3. Crossbreak unlined ducts and duct panels larger than 48 inch or bead 12 inches on center.
4. Securely anchor ducts to building structure with specified duct hangers attached with screws. Do not hang more than one duct from a duct hanger.
5. Brace and install ducts so they shall be free of vibration under all conditions of operation.
6. Ducts shall not bear on top of structural members.
7. Make duct take-offs to branches, registers, grilles, and diffusers as detailed on Drawings.
8. Ducts shall be large enough to accommodate inside acoustic duct liner. Dimensions shown on Drawings are net clear inside dimensions after duct liner has been installed.
9. Properly flash where ducts protrude above roof.
10. Install internal ends of slip joints in direction of flow. Make joints air tight using specified duct sealer.
11. Cover horizontal and longitudinal joints on exterior ducts with two layers of Hardcast tape installed with Hardcast HC-20 adhesive according to Manufacturer's recommendations.
12. Paint ductwork visible through registers, grilles, and diffusers flat black.

B. Install flexible inlet and outlet duct connections to each furnace, fan, fan coil unit, and air handling unit.

C. Install concealed ceiling damper regulators.
   1. Paint cover plates to match ceiling tile.
   2. Damper regulators will not be required for dampers located directly above removable ceilings or in Mechanical Rooms.

D. Provide each take-off with an adjustable volume damper to balance that branch.
   1. Anchor dampers securely to duct.
   2. Install dampers in main ducts within insulation.
   3. Dampers in branch ducts shall fit against sheet metal walls, bottom and top of duct, and be securely fastened. Cut duct liner to allow damper to fit against sheet metal.
   4. Where concealed ceiling damper regulators are installed, provide a cover plate.

E. Install grilles, registers, and diffusers. Level floor registers and anchor securely into floor.

F. Air Turns:
   1. Permanently installed, consisting of single thickness curved metal blades with one inch straight trailing edge to permit air to make abrupt turn without appreciable turbulence, in 90 degree elbows of above ground supply and return ductwork.
   2. 4-1/2 inch wide minimum vane rail. Do not use junior vane rails.
   3. Double thickness vanes not acceptable.
   4. Quiet and free from vibration when system is in operation. See SMACNA Manual

G. Install motorized dampers

END OF SECTION

VARIABLE AIR VOLUME BOXES

SECTION 23 31 15

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Variable volume terminal units.

B. Integral sound attenuator.

C. Integral heating coils.

D. Integral damper motor operators.

1.2 RELATED REQUIREMENTS

A. Section 23 0501 - Common HVAC Requirements.

B. Section 23 0900 – Building Automation Control System.

C. Section 23 2113 - Hydronic Piping.

D. Section 23 2116 - Hydronic Specialties: Connections to heating coils.

E. Section 23 3114 – Low Pressure Steel Ductwork.

F. Section 23 3713 - Air Outlets and Inlets.

1.3 REFERENCE STANDARDS

A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilation Systems; National Fire Protection Association; 2009.

B. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.4 SUBMITTALS

A. See Section 01 3300 – for submittal procedures.

B. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.

C. Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.

1. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 1 to 4 inch wg (250 to 1000 Pa).

D. Manufacturer's Installation Instructions: Indicate support and hanging details, and service clearances required.

E. Project Record Documents: Record actual locations of units.

F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

G. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.6 WARRANTY

A. See Section 01 7700 - Closeout Procedures, for additional warranty requirements.

B. Provide five year manufacturer warranty for air terminal units.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Price: www.price-hvac.com

B. Trane: www.trane.com

C. Titus: www.titus-hvac.com.

D. Substitutions: See Section 01 2500

2.2 MANUFACTURED UNITS

A. Ceiling mounted variable air volume supply air control terminals for connection to single duct, central air systems, with electric variable volume controls, and hot water heating coils.

B. Identify each terminal unit with clearly marked identification label and air flow indicator. Include unit nominal air flow, maximum factory set airflow, minimum factory set air flow, and coil type.

2.3 SINGLE DUCT VARIABLE VOLUME UNITS

A. Basic Assembly:
   1. Casings: Minimum 22 gage (0.8 mm) galvanized steel.
   2. Lining: Minimum 1/2 inch (13 mm) thick neoprene or vinyl coated fibrous glass insulation, 1.5 lb/cu ft (24 g/L) density, meeting NFPA 90A requirements and UL 181 erosion requirements. Face lining with mylar film.
   3. Plenum Air Inlets: Round stub connections for duct attachment.
   4. Plenum Air Outlets: S slip and drive connections.

B. Basic Unit:
   1. Configuration: Air volume damper assembly inside unit casing. Locate control components inside protective metal shroud.
   2. Volume Damper: Construct of galvanized steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 2 percent of design air flow at 1 inches (0.25 kPa) rated inlet static pressure.
   3. Mount damper operator to position damper normally open.

C. Attenuator Section: Line attenuator sections with 2 inch (50 mm) thick insulation.

D. Pick-up sensor.

E. Hot Water Heating Coil:
   1. Construction: 1/2 inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.
   2. Capacity: As scheduled.

F. Automatic Damper Operator:
   1. Electric Actuator: 24 volt with high limit. Refer to Section 23 0900.

G. Thermostat: Wall-mounted DCC type with appropriate mounting hardware. Refer to Section 23 0900.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide and install ceiling access doors or locate units above easily removable ceiling components.

C. Support units individually from structure. Do not support from adjacent ductwork.

D. Connect to ductwork in accordance with Section 23 3100.

E. Provide lined ductwork downstream of units.

F. Verify that electric power is available and of the correct characteristics.

3.2 ADJUSTING

A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to 0 percent full flow. Set units with heating coils for minimum 50 percent full flow.

END OF SECTION

UNDERGROUND DUCTWORK

SECTION 23 31 23

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install underground ductwork as described in Contract Documents.

PART 2 - PRODUCTS

2.1 DUCTWORK

A. Fiberglass-reinforced plastic duct system by Peabody Spunstrand Inc, 810 AGC Building, 1200 Westlake Avenue N, Seattle, WA 98109 (206) 282-5449
   1. Duct Tape - Sealtite PS401 sealing tape by Spunstrand Inc.

B. PVS or PVC coated galvanized steel duct with 4 mil thick coating on outside and on inside.
   1. Duct shall have and bear mark of approval of building code (ICBO, BOCA, etc) in authority for this Project.
   2. Gauges shall be as follows and be marked on each duct section. Corrugate ducts 14 inches in diameter and larger.

Size	Gauge
4" to 8"	26
9" to 12"	24
14" to 22"	22
24" to 28"	20
30" to 40"	18

   3. Make duct connections with Hardcast tape.

2.2 JOINT SLEEVES

A. Galvanized sheet metal. Galvanizing shall meet requirements of ASTM A 527-85, "Specification for Sheet Steel Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality", G 60.

Size	Gauge	Width
4" to 12"	26	4"
14" to 24"	24	4"
26" to 36"	22	6"

2.3 METAL BOOTS

A. 20 gauge galvanized steel. Galvanizing shall meet requirements of ASTM A 527-85, "Specification for Sheet Steel Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality", G 60.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Spunstrand:
   1. Join duct sections with galvanized sheet metal sleeve inside of duct secured with sheet metal screws.
   2. Wipe joint area clean and apply one layer of tape. Tape shall cover all screw heads.
   3. Construct sheet metal boot with 1-1/2 inch flange to fit against duct. Attach boot with self-tapping sheet metal screws, pulling boot flange snug to duct surface and tape joints. Tape shall cover screw heads.
   4. Encase boot completely in concrete, covering well around and below taped joint.

B. PVS or PVC Covered Duct:
   1. Install 6 mil polyethylene vapor barrier around duct.
   2. Fittings shall be PVS or PVC.
   3. Join duct sections, fittings, and boots with sheet metal screws as detailed on Drawings.
   4. Wrap duct connections, including boot connections to ducts, with 2 layers of hardcast tape installed with Hardcast HC-20 adhesive in accordance with Manufacturer's recommendations. Cover screw heads with tape.
   5. Encase boot completely in concrete, covering well around and below taped joint.
   6. Where PVS or PVC coating has been scratched, scuffed, or peeled during shipping or installation, cover exposed metal with coating compound recommended by Manufacturer and in accordance with his recommendations.

END OF SECTION

HIGH PRESSURE DUCT

SECTION 23 31 82

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install high pressure duct systems as described in Contract Documents.

PART 2 - PRODUCTS

2.1 ROUND AND OVAL

A. Ducts so designated and supplying air to VAV boxes shall be of spiral lockseam conduit. The conduit shall be fabricated from high quality, bright spangled, open-hearth, galvanized steel and shall be formed with a reinforcing rib on the outside filled with sealant and smooth interior. All duct and fittings shall be for 6 inch WG static pressure.

B. Fittings shall be fabricated from galvanized sheets with longitudinal and transverse seams welded and coated inside and out with rust inhibiting paint. Branch take-off from tees and laterals shall be welded to the trunk body by means of everdure welding. The fittings shall be formed with a roll shoulder against which the pipe shall be butted in installation.

C. Pipe and fittings shall be joined using adhesive recommended by the duct manufacturer painted on the male and female end of the pipe and fittings, pushed into place, fastened with No. 7x3/4 sheet metal screws, wrapped with three layers of fiberglass tape, 2 inches wide.

D. Flat-oval ducts shall be installed where shown with fittings of like type and shall be reinforced on the outside with angle iron as detailed and as recommended by the duct manufacturer if the width exceeds twice the height.

E. Vertical duct risers shall be supported at each floor by angle iron welded to ducts and connected to building structure at each floor.

F. High pressure duct and fittings shall be manufactured by same manufacturer and shall have guaranteed pressure ratings.

G. Approved Manufacturers:
1. Team Mechanical
2. United Sheet Metal
3. Lewis Corp.

H. Duct Sealant - SMACNA duct sealant class "A".

2.2 HIGH PRESSURE FLEXIBLE DUCT

A. High pressure flexible duct used upstream of terminal boxes shall be rated UL-181 Class 1 air duct and approved by NFPA 90A and 90B.

B. Thermal conductance: C=.23.

C. Rated for working pressure of 15 inches WG and with a velocity of up to 6,000 FPM.

D. Temperature range rated to 250 deg. F.

E. Core fabric shall be glass fiber reinforced copolymer impregnated through fire retardant fabric with low smoke and flame ratings.

F. Interior:
1. Smooth with no seams for laminar air flow
2. Low pressure drop
3. No dust collecting crevices
4. Leakproof

G. Insulation shall be 1" x 1# density glass fiber.
1. Vapor barrier shall be scuff resistant and be cuffed at both ends for overlap.
2. Joints and connections shall be made with two 1/2" wide positive locking steel or plastic straps. One strap shall attach the inner liner and a second strap shall strap the vapor barrier and insulation so they cover 1" past the inner liner.
3. Duct tape will not be used.
4. Approved Manufacturers:

H. Genflex IMPR

2.3 ACOUSTICAL LINED HIGH PRESSURE DUCT

A. 1 inch acoustical duct insulation between outer duct wall and an inner perforated metal liner.

B. Construction shall give specified acoustic impedance for noise reduction and have mechanical means to maintain positive concentricity of liner with shell and protect against any fiber entrainment.

C. Insulation shall have a thermal conductivity of 0.27.

D. Approved Manufacturers:
1. United Sheet Metal "Acousti-K27"
2. or approved equal

PART 3 - EXECUTION

3.1 TESTING

A. High pressure duct system shall be tested in sections after installation.
1. Test shall consist of placing each sealed section under a pressure of 8 inches WG. Air lost by leakage shall not exceed 1/2% of the total air quantity.
2. If above test indicates duct leaks beyond conditions specified, joints in ducts shall be treated with soap solution and leaks repaired until above specified conditions are obtained.
3. Tests shall be conducted in presence of Engineer.

B. Large vertical risers and ducts in fan room shall be tested with system in operation using soap solution to detect leaks. Leaks indicated by actively blowing bubbles shall be

repaired.

C. Actual method used shall be as recommended by duct manufacturer.

END OF SECTION

FLEX DUCT

SECTION 23 33 46

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install supply air branch duct runouts to diffusers as described in Contract Documents.

PART 2 - PRODUCTS

2.1 DUCTS

A. Formable, flexible, circular duct which shall retain its cross-section, shape, rigidity, and shall not restrict air flow after bending.

B. Nominal 1-1/2 inches thick, 3/4 lb/cu ft density fiberglass insulation with air-tight, polyehtylene or polyester core, sheathed in seamless vapor barrier jacket factory installed over flexible assembly.

C. Assembly, including insulation and vapor barrier, shall meet Class I requirement of NFPA 90A and be UL 181 rated, with flame spread of 25 or less and smoke developed rating of 50 or under.

D. Length of flexible ductwork shall not exceed 8'-0".

2.2 APPROVED MANUFACTURERS

A. ANCO-FLEX - 4625

B. Flex-Aire - PF/UPC #090

C. Hart & Cooley - F114

D. Thermaflex - G-KM

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct in fully extended condition free of sags and kinks.

B. Make duct connections by coating exterior of duct collar for 3 inches with duct sealer and securing duct in place over sheet metal collar with 1/2 inch wide metal cinch bands and sheet metal screws.

END OF SECTION

EXHAUST FANS

SECTION 23 34 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install exhaust fans as described in Contract Documents.

1.3 QUALITY ASSURANCES

A. Requirements of Regulatory Agencies:
   1. Bear AMCA seal and UL label.

PART 2 - PRODUCTS

2.1 CEILING MOUNTED EXHAUST FANS

A. Acoustically insulated housings.

B. Sound level rating of 4.6 sones maximum for fan RPM and CFM listed on Drawings.

C. Include chatterproof integral back-draft damper with no metal to metal contact.

D. True centrifugal wheels.

E. Entire fan, motor, and wheel assembly shall be easily removable without disturbing housing.

F. Suitably ground motors and mount on rubber-in shear vibration isolators.

G. Provide wall or roof cap, as required.

H. Approved Manufacturers:
   1. Cook-Gemini
   2. Greenheck Sp
   3. Pace
   4. Penn Zephyr
   5. Twin City

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anchor fan units securely to structure or curb.

END OF SECTION

AIR OUTLETS & INLETS

SECTION 23 37 13

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install wall supply registers, transfer grilles, return air grilles, soffit grilles, ceiling diffusers, louvers connected to ductwork, and registers as described in Contract Documents.

PART 2 - PRODUCTS

2.1 GRILLES & REGISTERS

A. Approved Manufacturers:
   1. Price
   2. Anemostat
   3. Krueger
   4. Titus
   5. Tuttle & Bailey

2.2 SPIN-IN FITTINGS

A. Low pressure round take-offs to diffusers shall be made with spin-in fittings. They shall incorporate a manual balancing damper. The damper shall be spring loaded and a positive locking wing nut shall secure the damper position.

B. Approved Manufacturers:

   1. Sheet metal fittings: Genflex DB-1DEL, Hercules

PART 3 - EXECUTION

3.1 INSTALLATION

A. Anchor securely into openings.

B. Install with screws to match color and finish of grilles and registers.

C. Touch-up any scratched finish surfaces.

D. Install in accordance with manufacturer's instructions.

E. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

F. Install diffusers to ductwork with airtight connection.

G. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.

H. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 9000.

END OF SECTION

DISPOSABLE FILTERS

SECTION 23 41 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install filters used in mechanical equipment.

PART 2 - PRODUCTS

2.1 AIR HANDLING UNIT FILTERS

A. 2-inch-thick, medium efficiency, disposable type pre-formed pleated design, having at least 4.5 sq ft of filtering media per sq ft of face area.

B. Media shall be reinforced non-woven cotton fabric, treated with adhesive similar to "Vyclad B" and continuously laminated to supporting steel wire grid conforming to configuration of pleats.

C. Media pack shall be sealed in a chipboard frame or beverage board.

D. Filters shall have rated average efficiency of 25 to 30% on ASHRAE Test Standard 52-76 and be capable of operating with variable face velocities up to 500 FPM without impairing efficiency.

E. Initial resistance shall not exceed 0.30 inches w.g. at 500 FPM or 0.14 inch w.g. at 300 FPM. Filter shall be listed Class 2 by UL.

F. Approved Manufacturers:
1. Type 30/30 by Farr Co
2. Mark 80 by Serv-Aire
3. HC Type 40 by Envopleat
4. DP2-40 by Air Guard

END OF SECTION

HEATING BOILERS

SECTION 23 53 15

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install heating boilers as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Boiler shall be AGA design certified for a minimum boiler efficiency of 80% and bear appropriate seal.

B. Boiler shall meet requirements of ASME Boiler and Pressure Vessel Code for 160 psi working pressure and shall bear ASME seal and registration number of National Board of Boiler and Pressure Vessel Inspectors.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Equipped for natural gas.

B. Designed specifically for hot water heating systems and specifically designated as such by manufacturer.

C. Atmospheric type using titanium stainless steel burners.

D. Shall not require blower motors to supply combustion air or to create venting action.

E. Fuel-air mixture shall be factory set for maximum combustion efficiency and shall be tamper-proof in the field.

F. Completely assembled with a built-in draft diverter.

G. Heat Exchanger: Boiler shall be of straight tube design and shall have no blind passages or concealed pockets. Water containing parts shall be designed so they are continually scoured to prevent any build-up of sludge that would necessitate periodic blow down.

1. Inspection covers permitting inspection of wet internal surfaces shall be provided on headers at each end and held in place by corrosion resistant steel cap screws. Waterways shall be copper or bear fused ceramic coating to positively protect boiler from corrosion.
2. Entire wet section of boiler shall be removable and replaceable without damage or disassembly of combustion chamber and/or burner sections.
3. Water tubes shall be made of integral-finned copper tubing of 7/8 inch I.D. x .065 wall thickness with fins of .40 inch minimum height spaced at 7 fins per inch. The tubes shall be rolled directly into an ASME header of grey cast iron protected by

a ceramic coating fused into the metal at not less than 1300 deg. F. Non-metallic gaskets shall be exterior to jacket structure and combustion chamber to avoid deterioration from heat. Complete heat transfer section shall be hydrostatically tested at 400 psi, be ASME inspected and approved, and protected by an ASME pressure relief valve.

H. Combustion Chamber and Jacket: Combustion chamber shall be lined with a castable refractory approved for service temperatures at not less than 2100 deg. F. Outer jacket shall be unitized shell and frame construction fabricated of galvanized steel and finished with acrylic thermoset paint baked on at not less than 325 deg. F.

I. Controls: Ignition safeguards shall be provided as follows:
   1. System 9 - Standard on natural gas units:
      a. Electronic pilot flame supervision
      b. Main gas shutdown 1 second after pilot failure
      c. Automatic pilot ignition on start-up
      d. Automatic pilot re-ignition if pilot is extinguished
      e. Solid state components.

J. Firing Option: Boiler shall be provided with 4-stage firing with automatic temperature reset control.

K. Multimatic Sequence Control System for Input Modulation: Teledyne Laars Multimatic Sequence Control System is an electronic package that provides central control for a heating system. Simple wiring connections between panel and boilers will change individual boilers into a single, cohesive step control heating system.
   1. The heart of Teledyne Laars' Multimatic Sequence Control System is a versatile control panel made up of a solid state signal center with throttling range adjustment and system temperature reset ratio adjustment and a proportional staging control of four stages.
   2. Provide with Outdoor Reset: Multimatic Sequence Control System shall come with an electronic immersion sensor for mounting in system water line and an electronic outdoor temperature sensor.

L. Approved Manufacturers:
   1. Teledyne Laars
   2. or approved equal

END OF SECTION

ELECTRIC RADIANT WALL HEATERS

SECTION 23 55 40

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

A. Furnish and install wall heaters as described in Contract Documents.

1.3 QUALITY ASSURANCE

A. Units shall be UL listed and comply with NEC.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Fan type for recess mounting in wall.

B. 20 gauge minimum sheet metal casing.

C. Heating element shall be encased in steel finned casting and protected by thermal switch.

D. Fan motor shall be heavy duty enclosed and permanently lubricated.

E. Fan shall be precision balanced and fan-motor assembly mounted to be vibration free.

F. Units shall be controlled automatically by integral thermostat when heater is in "ON" position.

G. Heater shall have built-in fan delay.

H. Finish - Baked-on enamel.

I. Approved Manufacturers:
1. Q' Mark
2. Berko
3. Thermador
4. Markel

2.2 WALL UNIT HEATERS

A. Recessed wall unit heaters with capacity as shown.

B. Intergral screwdriver operated thermostats.

C. Heavy duty blower fan with transformer.

D. Sheathed heating elements.

E. Automatic reset thermal cutout switch and dissipation switch.

F. Approved Manufacturers:
   1. Q' Mark
   2. Electricmode

END OF SECTION

AIR HANDLING UNIT / DEDICATED OUTDOOR AIR SYSTEM / ENERGY RECOVERY UNIT

SECTION 23 74 13

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This specification is based on an Air Handling Unit model as manufactured by Annexair Inc. Manufacturers of alternate equipment must be approved to bid via addendum, in writing by the specifying engineer, at least two weeks prior to bid time in order for their bid to be accepted by the contractor. If the equipment is not pre-approved then under no circumstances shall the contractor invest any time or money in receiving submittals or considering the equipment. Costs associated with dimensional, performance or other deviations from the specified equipment, including engineering costs to evaluate such deviations, shall be paid by the contractor

B. The unit(s) shall be installed in strict accordance with the specifications. Unit(s) shall be complete with all components and accessories as specified. All units shall be factory assembled, internally wired, and 100% run tested to check operation, fan/blower rotation and control sequence before leaving the factory. Wiring internal to the unit shall be numbered for simplified identification. Units shall be ETL listed and labeled, classified in accordance with ANSI-UL 1995 / CAN/CSA C22.2 No.236.

C. Equipment start-up and project inspection by qualified factory trained representative.

1.2 QUALITY ASSURANCE

A. All unit(s) shall be factory run tested before shipping. A proof copy of the test shall be placed in the unit electrical power & control panel.

B. Unit(s) shall bear the ETL label, tested in accordance to UL 1995. Electrical components shall be UL listed.

C. Fans shall be tested in an AMCA certified laboratory; insulation shall comply with NFPA 90A.

D. Coils shall be tested in accordance to AHRI 410.

E. Energy recovery exchangers shall be in accordance to AHRI 1060, “Rating Air-to-Air Energy Recovery Equipment” and Eurovent standards.

F. Filters shall be tested in accordance to ASHRAE 52.

G. The unit manufacturers construction shall have an independent testing agency test the air leakage, panel deflection and sound pressure levels for supply airflows of minimum 20,000 CFM. The air leakage of the unit(s) shall not exceed 1% at 8” inches H_2O positive static pressure and a copy of the report must be submitted upon request. Unit shall be constructed to limit frame and panel deflection to $1/250^{th}$ of the panel length at 8” inches H_2O positive static pressure and a copy of the report must be submitted upon request. The unit shall also be tested in accordance with ANSI S12.34-1998 and instrumentation used must follow the requirements of AMCA 300 for sound readings. The sound tests conducted shall report overall sound power and pressure readings for supply air outlet, return air inlet and casing radiated.

H. Products shall be supported with a warranty that ensures the product will be free from defects in materials and workmanship for a period of one year after shipment.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 15XXX. Include product description,

model, dimensions, component sizes, rough-in requirements, service sizes, and finishes. Include rated capacities, operating weights, furnished specialties, and accessories.

B. Submit manufacturer's installation instructions.

C. Submit operation and maintenance data.

D. Submit coordination drawings. Include unit details, plans, elevations, sections, details of components. Show support locations, type of support, weight and required clearances.

E. Submit wiring diagrams including power, signal, and control wiring.

1.4 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.5 WARRANTY

A. Annexair warrants each product to be free from defects in material and workmanship under normal and proper use, and will within twelve (12) months from date of startup and not exceed eighteen (18) months from shipment, repair or replace any part which, when returned to our factory transportation charges prepaid, and upon inspection by Annexair, proves to be defective. This warranty does not include any labor or service charges that occur under this warranty. Minimum (5) five-year compressor warranty shall be provided, parts only – labor not included

B. The installing contractor must be responsible for warranty service and maintenance after the equipment is placed into operation.

C. NOTIFICATION: Any modification to the Annexair equipment, including the controls and sequence of operation, without specific approval in writing by Annexair, will result in a violation of the equipment warranty

1.6 REFERENCES

All components selected for this project shall conform to the following Standards:

A. AFBMA 9: Load Ratings and Fatigue Life for Ball Bearings

B. AMCA Standard 99: Standards Handbook

C. AMCA /ANSI Standard 204: Balance Quality and Vibration Levels for Fans

D. AMCA Standard 210: Laboratory Methods of Testing Fans for Ratings

E. AMCA Standard 300: Reverberant Room Method for Sound Testing of Fans

F. AMCA 320; Laboratory Method for Sound Testing of Fans Using Sound Intensity

G. AMCA Standard 500:Test Methods for Louvers, Dampers and Shutters

H. AHRI Standard 1060: Air-to-Air Energy Recovery Ventilation Equipment

I. AHRI Standard 410: Forced-Circulation Air-Cooling and Air-Heating Coil

J. ASHRAE Standard 52: Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter

K. ASHRAE 52.2: Procedures for Testing Air Cleaning Devices Used for Removing Particulate Matter

L. ASHRAE 84-91: Method of Testing Air-to-Air Heat Exchangers

M. ASHRAE/ANSI Standard 111: Practices for Measurement, Testing, Adjusting and

Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems

N. ASTM A-525: Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

O. NEMA MG-1: National Electrical Manufacturers Association Motor Standards

P. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems

Q. SMACNA: Sheet Metal and Air Conditioning Contractors National Association

R. UL Standard 1995: Heating and Cooling Equipment

S. UL Standard 900: Test Performance of Air Filter Units

1.7 COORDINATION

A. Coordinate location and installation of air-handling units. Revise locations and elevations to suit field conditions and to ensure proper operation.
B. Coordinate location and installation of air handling units with the electrical, mechanical, and plumbing contractors.

PART 2 - PRODUCTS

2.1 HOUSING

A. THERMO-COMPOSITE PANELS (*with thermal break frame*)

1. The unit housing shall be no-through metal with 2'' Thermo-Composite and foam panel construction - interior and exterior or an all-aluminum 4" Foam thermal break construction - interior and exterior. Thermal break construction using a gasket to insulate two panels is not an acceptable equivalent to a no-through metal constructed casing. No-through metal construction will be inherent to all the component construction in the assembly.
2. All panels and access doors shall be double wall construction with R14 foam insulation for every 2" of construction. All foam insulation must be Greenguard certified®. Any insulation incorporating CFCs or HCFCs in its construction is strictly prohibited from this application.
3. Unit casing will have no exterior condensation at interior AHU temperatures down to 43F while unit exterior conditions are maintained at 95 F dry bulb / 85 F wet bulb. The air handling unit manufacturer general construction shall be tested to demonstarate the thermal performance of the unit casing. The test shall include placing the entire test unit in a climate-controlled environment and exposing the unit to the conditions mentioned previously. If the manufacturer does not have access to such equipment, an independent testing agent must be hired to transport the test unit to a qualified test facility and perform the test at the expense of the manufacturer. Inability to provide this option to the engineer will make the manufacturer ineligible to bid on this project he unit housing shall be constructed from a frame, base and panel assembly. Unit shall be completely factory assembled and shipped in one piece as shown on drawings.
4. The panels shall be tested in accordance with SMACNA and ASHRAE 111 to have a deflection of no more than L/1150 at 10'' and withstand air pressures up to 8" w.c with less than 1% leakage. Fire resistance of the panel will be in compliance with UL 94 rated at 5VA; and a flame spread / smoke development in compliance with UL 723 ASTM E84 Class 1 rating.
5. Thermo-Composite or aluminum panels shall be provided for the entire unit construction, including but not limited to, walls, doors, floors, roof, interior partitions, and electrical compartment. Panels shall be non-load bearing type.
6. The frame shall consist of anodized extruded aluminum profiles which incorporates a thermally broken construction; welded together for reinforcement and insulated

for superior thermal performance.

7. Base structure shall be fully welded G-90, painted exterior, and have integral lifting lugs which can be removed once the unit is installed.
8. All roof and side wall seams shall be positively sealed to prevent water and air leakage. The OA and EA compartment shall have 1" PVC drains extended to exterior of unit
9. Access doors shall be provided to all major components to facilitate quick and easy access. Access doors will be made from the same material as the unit casing and shall incorporate thermal break construction. Fan access door(s) shall have Allegis type handles, with one handle interlinking multiple latches and threaded insert fastening handles for all remaining doors. If access doors do not open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement. Removable panels provided for equipment pull out for coil(s), and air to air heat exchanger section(s) shall have key tooled threaded insert fasteners. Hinges shall be Nylon hinge type designed to open 180 degrees.
10. Unit shall have the entire exterior finished with a PVDF coating designed for UV resistance. Panels shall be painted Annexair standard color white gray RAL 9002. If custom color is required, please specify the associated RAL color code. Panels shall pass ASTM B117 3000-hour salt fog resistance test and ASTM D4585 3000-hour moisture condensation resistance test. In addition, paint must meet AAMA 620-02 standard for color, chalking, gloss retention, and abrasion resistance.
11. The air handler unit casing shall be provided with a lifetime warranty against corrosion under normal use.

B. STD-G90 PANELS

1. The unit housing shall be constructed from a frame, base and panel assembly. Unit shall be completely factory assembled and shipped in one piece as shown on drawings.
2. The frame shall consist of robust die cast corners and extruded aluminum profiles welded together for reinforcement. Optional Thermal break frame shall be provided.
3. The base structure shall be fully welded with formed heavy gauge galvanized steel. Double lined heavy-duty galvanized steel, G-90 floor insulated with R12 foam shall be mechanically fastened to the base structure which shall consist of an anti-vibration gasket to diminish the metal to metal contact. Base structure shall have galvanized integral lifting lugs which can be removed once the unit is installed.
4. All roof and wall panels shall be made from G-90 galvanized steel, minimum 18-gauge exterior and 20-gauge interior. All panels and access doors shall be double wall construction with (R-8.6) two-inch thick, minimum 1.8 PCF fiberglass insulation. Panels shall be fastened from the interior and gasketed along the frame to reduce thermal transmission. Fixed panels shall be removable without affecting the housing integrity.
5. Access doors shall be provided to all major components to facilitate quick and easy access. Fan access door(s) shall have Allegis type latches, lockable ready, and threaded insert fastening handles for all remaining doors. If access doors do not open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement. Removable panels provided for equipment pull out for coil(s) and air to air heat exchanger(s) shall have key tooled threaded insert fasteners. Hinges shall be heavy duty aluminum butt hinges designed to open 180 degrees. Access doors shall be sealed with a full "U-Shaped" gasket for superior air tightness along the door edge. Bulb type gaskets shall not be acceptable since they do not return to their original form once compressed.
6. The airflow separation wall between the outside air intake and exhaust air outlet

shall be a one-inch double wall insulated with R-4.3.

7. Floor openings shall be covered with 1” fiberglass safety walk on gratings.
8. All roof and side wall seams shall be positively sealed to prevent water and air leakage.
9. The OA and EA compartment shall have 1” PVC drains extended to exterior of unit.
10. Outdoor units shall have a rain gutter above each access door and a watertight roof shall be provided with a white TPO UV-reflective membrane. Indoor units shall not have the TPO membrane.
11. Units shall have the entire exterior finished with (2) two coats of acrylic urethane enamel, Annexair standard Gray white RAL 9002. If custom color is required, please specify the associated RAL color code. Paint shall pass ASTM B117 2000-hour salt fog resistance test and ASTM D4585 2000-hour moisture condensation resistance test.

C. WEATHER HOODS

The outdoor intake weather hood shall be completely constructed in aluminum for superior corrosion resistance. The hood shall ship loose for field installation by the installing contractor. Painted galvanized hoods shall not be acceptable due to its susceptibility to corrosion. The outdoor air hood shall be designed with a 4” extruded aluminum louver, bird screen and a plenum enclosure with drain holes. The louver blades shall be drainable type with a maximum 45-degree angle and curved with integral rain baffle. The louver design shall not allow more than 0.03 oz/ft2 water penetration when tested in accordance to AMCA 500. The pressure drop of the complete hood assembly shall not exceed 0.05”wc at a maximum 500 fpm face velocity. A Pre-filter rack system shall be installed within the weather hood enclosure to prevent outdoor air dust and debris from entering the damper and unit casing plenum. Pre-filters installed inside the unit casing plenum and downstream of the outdoor damper will not be acceptable as this will increase overall maintenance on the damper, reduce indoor air quality and promote mold and bacteria growth. Filter access in the hood shall be accomplished via the louver that is installed with a stainless steel piano hinge and spring loaded latch. No tools or ladders shall be required to access the pre-filters in the weather hood assembly be and header insulation constructed from 304 stainless steel shielding for increased energy efficiency and reduced airstream heat gain. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide airgap to minimize conduction and The unit housing

D. EXHAUST AIR LOUVER

The exhaust air outlet louvers shall be 2” extruded aluminum, with non- restricting blade design and bird screen.

2.2 FANS

A. PLENUM FANS (ER model)

1. Fans shall be direct drive radial centrifugal fans with free running impeller. No fan belts will be acceptable for this application. Fans shall be compact, optimized and construction made of galvanized sheet steel with backward curved 7-blade high efficiency impeller, protected by an epoxy powder coating.
2. To reduce vibration, the impeller shall be balanced with hub to an admissible vibration severity of less than 2.8 mm/s in conformity with DIN ISO 14694 and proof shall be supplied for each individual impeller. Tests shall be made according to DIN ISO 1940 Part 1, quality of balancing G2.5/6.3.
3. The single inlet shall be mounted onto constant speed direct drive motor, equipped with an air flow optimized inlet cone from galvanized sheet steel.

4. Fans shall be completely certified as per ISO 5801 and in accordance to AMCA standards.
5. Fan/ fan bank will require to be operated by a Variable speed drive or one VFD per fan shall be provided w/Backdraft Isolation damper at the event of a fan failure .
6. Optional: Plenum fan shall come equipped with guard grilles for the air intake side.

B. PLUG FANS (GR model)
1. Wall mounted, direct driven plenum fans (horizontal or vertical) shall be installed with perimeter gasketed isolation.
2. Fans shall be direct drive radial centrifugal fans with free running impeller. Fans shall be compact, optimized and construction made of galvanized sheet steel with backward curved 7-blade high efficiency impeller, protected by an epoxy powder coating.
3. To reduce vibration, the impeller shall be balanced with hub to an admissible vibration severity of less than 2.8 mm/s in conformity with DIN ISO 14694 and proof shall be supplied for each individual impeller. Tests shall be made according to DIN ISO 1940 Part 1, quality of balancing G2.5/6.3.
4. The single inlet shall be mounted onto constant speed direct drive motor, equipped with an air flow optimized inlet cone from galvanized sheet steel.
5. Fans shall be completely certified as per ISO 5801 and in accordance to AMCA standards.
6. Fan/ fan bank will require to be operated by a Variable speed drive or one VFD per fan shall be provided w/Backdraft Isolation damper at the event of a fan failure .
7. Optional: Plenum fan shall come equipped with guard grilles for the air intake side.

C. FAN ISOLATIONS
1. The fan housing and motor assembly shall be isolated from the unit cabinetry with a minimum 95% efficient spring isolators or high efficiency rubber isolators or seismic isolators.
2. In addition, fans shall have flexible canvas to reduce vibration transmission.

D. SOUND ATTENUATION IN FAN COMPARTEMNT (OPTIONAL)
1. The fan section shall be constructed with a perforated interior liner, same construction as the housing interior lining and shall be insulated with Permacote anti-microbial coating fiber glass. The perforated lining shall be installed on fixed panels only, with exception on the interior ceiling

2.3 FAN MOTORS

A. The fan motors shall meet NEMA standard dimensions and comply with the Energy policy Act of 1997.
B. Motors shall have premium efficiencies with low noise and vibration output. Motors shall be certified and built in accordance to ISO 9001 quality control system
C. Motors shall have ODP enclosure with Premium efficiency performance.
D. Units shall be designed for constant application. Please refer to the unit schedule for the application type.
E. Option: A shaft grounding brush kit will be provided to prevent electrical damage to motor bearings by safely channeling harmful shaft currents to ground.

2.4 VARIABLE FREQUENCY DRIVE (VFD)-ABB

A. VFDs will be used to set or regulate the fan speed and airflow for these units.
B. The VFD shall have PID function for constant flow applications
C. The VFDs will be installed with integral brake transistor, overload protection, and adjustable pulse-width modulation (PWM).
D. The VFD shall use Insulated Gate Bipolar Transistor (IGBT) technology to convert three

phase input power to coded PWM output and have 4-20mA analog output terminals that are fully programmable for variable flow applications.

E. The VFD shall be equipped with a keypad with status indicators, easy access functions, and monitoring functions during motor operation.

F. In the event of a momentary power failure or fault the VFD shall read the inverter speed and direction of a coasting motor and shall automatically restart the motor smoothly.

G. Technical support will be provided by the VFD manufacturer.

H. VFDs shall be installed as shown on drawings with contactors, relays, and all specified accessories.

I. VFDs will be installed WITHOUT by-pass.

2.5 FILTERS

A. PRE-FILTERS *(HIGH CAPACITY SERIES 400 2" MERV 10)*)

1. Filters shall be factory installed upstream of the heat exchanger and coils, in both airstreams.
2. The filters shall be Filtration Group Series 400, MERV 10.
3. Each filter shall consist of 100% synthetic media, expanded metal on the downstream and enclosing with high wet-strength beverage board with diagonal support bonded on air entering and air exiting side of each pleat.
4. MERV 10 model High Capacity Serie 400 filters, UL 900 classified are rated as per ASHRAE test 52.2.2012 at 88% efficiency initial (based on Minimum Average Efficiency) at 3-10 microns.
5. The model High Capacity Serie 400 could be operated at 500 FPM, surface area 18 FT2 of media based on 24 x 24 x 2 initial static pressure at 0.24”, final will be 1”.
6. Filters shall be placed in a completely sealed, galvanized holding frame with quick release latches for easy replacement.

2.6 DAMPERS

A. NON-INSULATED TAMCO SERIES *1000*

1. Dampers shall be installed where shown on the drawings.
2. Dampers shall be low leak type with rubber edges, opposed blades, and constructed from extruded aluminum.
3. Galvanized dampers will not be acceptable.
4. The exhaust air outlet shall have a standard aluminum gravity type damper, unless otherwise noted below.
5. Dampers shall be installed in the compartments (as shown on the drawings) with linkage rod for actuators
6. Actuators shall be 24V factory installed: two-position or modulating (please refer to the unit schedule).
7. All actuators shall have spring return mechanism and auxiliary switches. Dampers will be installed in the failed close positions unless otherwise noted

2.7 CONDENSING UNIT

A. AIR COOLED CONDENSING UNIT WITH VARIABLE SPEED COMPRESSORS (AEROMOD AZ)

1. Provide an integral air-cooled condensing section with variable speed compressors. The condensing section shall be factory piped, wired, and charged with R-410A refrigerant. The section shall be from the same manufacturer as the air handling unit. Factory mounting and piping an air-cooled condensing unit, provided by a third party is not acceptable. Furthermore, the exterior cabinet of the air-cooled section shall be of the same construction and paint color as the air handling unit.

2. Compressors shall be variable speed scroll type that can modulate from 30% to 100% capacity per compressor. Variable capacity compressors which do not modulate the speed of the scrolls are not considered equal to a variable speed scroll since they consume more energy at the same capacity output. Mechanically stepped scrolls which are unloaded via a digital signal to a solenoid valve, in a timed sequence, will not be acceptable for this application. The variable speed scrolls shall be operated via a factory supplied variable speed controller per compressor, and all tandem compressors will modulate in unison. Using a single variable speed controller on the lead circuit alone is not efficient during part load conditions, therefore will not be acceptable for this application. Each compressor and controller assembly shall be equipped with the following features: PERMANENT MAGNET MOTOR, electronic expansion valve, a crankcase heater function, anti-short cycling, built-in phase loss detector, EMC filter, oil return management system, and reverse rotation protection. All refrigeration parts, including the compressor and the speed controller will be located in a closed and vented service compartment, separate from the condenser coil airflow. Compressors located in compartments open to the outside are not acceptable. Compressors shall be mounted on rubber isolators to limit vibration transmission and shall include flexible hoses on both the suction and discharge refrigeration lines.
3. All air-cooled condensing units above 18 tons will have a minimum of two compressors.
4. Condenser fans shall have 7 air foil type blades with external mounted asynchronous motors that are class F insulated, IP54 and 100% variable speed. Each condenser fan bank shall be provided with a variable voltage controller which modulates via refrigerant head pressure control for superior part load performance. All the condenser fans in a fan bank shall modulate in unison for each respective circuit. Staging condenser fans are not an acceptable mode of control for head pressure control. Protective guards shall be included on all condenser fans, and condenser coils. The coil protective guards shall be ideal to keep coil at maximum operating performance, protect the condenser from hail damage and allow for easy cleaning with quick release latches. The condenser coils shall be micro-channel design for maximum efficiency performance, consist of a single pass arrangement with integral receiver, and be pressure tested at 650 psig. Coil construction shall consist of aluminum alloys for the fins, tubes and manifolds. Copper tube, aluminum fin condenser coils are not acceptable as they require more refrigeration charge for the same capacity output.
5. The following components shall be included in each refrigeration circuit: Liquid line filter dryer, hi and lo pressure switch, hi and lo pressure transducers, suction and liquid lines shutoff valves and suction line accumulators. In addition, refrigeration piping must use Shrader type connections for all components, including but not limited to valves and transducers. Under no circumstances shall the units leave the factory without a complete run test and a copy of the QC report shall be provided upon request.
6. Minimum (5) five-year compressor warranties shall be provided**.**

2.8 COILS

A. DX COILS

1. Coils shall be factory installed in the unit.
2. Coils shall be designed with respective circuits to match the design requirements. All coils shall have a distributor per circuit connection. Coils shall be circuited for counter-flow heat transfer to provide maximum mean effective temperature difference for maximum heat transfer rates.
3. Primary surface shall be round seamless (3/8” O.D.) copper tube staggered in the

direction of airflow. Secondary surface shall consist of rippled aluminum plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Headers shall have intruded tube holes to provide a large brazing surface for maximum strength and inherent flexibility.

4. Casing shall be constructed of continuous galvanized steel.
5. The complete coil shall be tested with 315 pounds air pressure under warm water and be suitable for operation at 250 psig working pressures. Maximum finned coil height shall be 60” and shall not exceed 500 FPM face velocity.
6. Drain pan shall be provided on cooling coils. Cooling coils shall sit on stainless steel tubular support rails, which shall stand a minimum of (2) two inches above the highest point of the floor drain pan. Stacked coils shall be provided for larger airflows and intermediate drain pans shall be provided for each coil bank. Drain pans shall be stainless steel with 1.25” stainless steel drain connections on one side only. Pan shall be sloped in two planes.
7. All coils shall be rated in accordance with AHRI standard 410.

2.9 BURNERS

A. INDIRECT GAS FIRED FURNACE (*HM SERIES*)

1. Furnish and install where shown on plans Gas-fired Duct Furnace Heat Module(s).
2. The module shall be a Recognized Component by Intertek Testing Services (ITS / ETL). All modules will have a minimum thermal efficiency of 80%.
3. The module shall employ a tubular heat exchanger and a draft inducer assembly to provide for positive venting of flue gases. Burner assemblies shall employ in-shot type burners constructed of aluminized steel body and sintered metal flame holder with integral carryover plenum.
4. The ignition system will include a 6000 V Igniter and flame rod detection. Ceramic hot surface ignition systems are unacceptable.
5. Gas-fired duct furnace(s) provided shall employ a tubular heat exchanger constructed of 18-gauge minimum, type 409 stainless steel, and 1 ¾” to 2 ¼” diameter having a minimum wall thickness of 0.047”. Tubes and shall be produced to ASTM A249 standards for heat exchanger application. Tubes shall employ integral formed-dimple restrictors to eliminate noise associated with expansion and contraction of internal baffles during heating cycles, and to provide for unobstructed drainage of condensate that occurs in the tubes during cooling operation. Drainage shall be configured so that burners and burner surfaces are not exposed to condensate during cooling system operation.
6. Full Modulation control shall be provided. On a call for heat and subsequent safe burner light OFF, the burner modulation shall be minimum 5:1, 10:1, 20:1 or 30:1 as noted on the schedule. Stepped modulation is not acceptable. Controls shall include an ignition control with alarm capable contact and one hour auto reset on lockout, roll out switch, high limit switch and a proving switch of loss of the induced draft fan. Additionally, on modulating and 2-stage systems all timing and switching functions shall be controlled through an electronic timer relay control. Staging controller available for 0 to 10VDC or 4 to 20mA input from building management control.
7. Burners will use Natural Gas (with gas pressure min 7''-max 14''wc) unless otherwise specified. Gas train compartment shall be provided with 1” PVC drain.

2.10 POWER AND SAFETY CONTROL

A. The power and control center shall be integral to the unit housing and rated equivalent to NEMA 3R.

B. Under no circumstances shall any wiring or parts be field installed. If units show up at the job site without wiring by the manufacturer, the contractor will have to send back units to the manufacturer at the contractors' expense to get them factory wired and re-tested.

C. Panels that are externally mounted to the unit shall not be accepted, regardless of the NEMA rating they may have. A separate access door shall be provided with an approved locking device.

D. All electrical components contained in the panel shall be UL/CSA certified and labeled. The unit shall be complete with VFDs, fuses, relays, phase protection for compressorized units, terminals for main ON/OFF and step-down transformer. All components shall be factory wired for single point power connection by the manufacturer of the unit. A non-fused safety disconnect switch shall be factory installed for ON/OFF servicing.

E. An electrical pipe chase for power and control feeding shall be provided next to the control panel.

F. Any power or control wiring that is field installed shall not be accepted under any circumstances. The Short Circuit Current Rating (SCCR) is 5 kA rms symmetrical, 600V Maximum or as noted on schedule.

G. GFI, lights, and switches shall be factory installed and wired to a common junction box. A separate power connection 120V/1 will be required (powered by others).

2.11 AIR TEMPERATURE CONTROL PACKAGE (OPTIONAL)

A. The unit shall be delivered with factory installed control system. Under no circumstances shall control be provided by other than the manufacturer of the equipment. Field installed control package by the ATC will not be acceptable.

B. The control system shall consist of a microprocessor with LCD display, 7 day time clock, 20 day holiday schedule, occupied/unoccupied mode switch, warm up mode, cool down mode, hi-lo limit discharge control, fan status, temperature and humidity sensors when applicable, scroll buttons to change settings as required and alarm history.

C. Supply air temperature and humidity sensors shall be provided by Annexair and field mounted in the supply duct and wired by others. Optional - Space temperature and humidity wall mounted sensors shall be field wired and installed by others.

D. Refer to the Sequence of Operation and control schematic for detailed description and options.

E. Communication Interface Card: The microprocessor shall be capable of communicating with the following protocol language: Select one of the following: Bacnet MS/TP RS-485 .

2.12 ADDITIONAL ACCESSORIES AND UNIT FEATURES (OPTIONAL)

A. Dirty filter switch

B. Rotation detector (where applicable)

C. Door interlocking switch (for fan section)

D. Magnehelic gauges (Dwyer 2000 model)

E. Condensate overflow switch (for drain pans)

F. OA Air Flow Monitoring Package – IAQ-TEK

G. The airflow measuring station shall consist of a special probe, a transducer and a display. The probe will be designed to be accurate in turbulent airflow and will be a standard design to fit all ducts. Only the number of probes will change based on the

surface area. Probes can be washed down if required. The high accuracy transducer shall be mounted inside a NEMA 4 enclosure where temperature is controlled and shall also include an auto-zero function to prevent drifting. The display will indicate airflow, temperature and alarms. It will also serve as the interface to configure the system via an internal Set-up Wizard. This Set-up Wizard will include start-up, commissioning and diagnostics functions without the use of a laptop computer or other tools. All calculations, and management operations will be done within the display unit. The accuracy shall be +/- 5% of reading between 200 and 965 ft/min and +/- 10% of reading between 75 and 200 ft/min. as per Tek-Air series IAQ-Tek.

H. Fan Airflow Monitoring Station Package

I. The unit shall be delivered with factory installed airflow measuring system. The airflow measuring system, consisting of a piezometer ring and transducer, shall be installed on the fan. The package consists of an inlet port on the fan inlet cone connected with flexible tubing to the transducer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install Air Handling Unit per manufacturers' instructions.

B. Install with required clearance for service and maintenance.

3.3 TESTING

A. System verification testing is part of the commissioning process. Verification testing shall be performed by the Contractor and witnessed and documented by the Commissioning Authority. Refer to section 01810, Commissioning, for system verification tests and commissioning requirements.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 TRAINING

A. Training of the Owner’s operation and maintenance personnel is required in cooperation with the Commissioning Authority. Provide competent, factory-authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to System Demonstrations, section 01670, for

contractor training requirements. Refer to section 01810, Commissioning, for further contractor training requirements.

B. Contact Annexair to request pricing to include factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.
   1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
   2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
   3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
   4. Schedule training with Owner, through Architect, with at least seven days advance notice.

END OF SECTION

END OF DIVISION